THE OXFORD GEOGRAPHIES

AUSTRALIA

PHYSIOGRAPHIC & ECONOMIC

BY

GRIFFITH TAYLOR

OXFORD: AT THE CLARENDON PRESS

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EDITED BY A. J. HERBERTSON

AUSTRALIA

IN ITS PHYSIOGRAPHIC AND ECONOMIC ASPECTS

BY

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PREFACE

When it fell to my duty to prepare a course of lectures at the University of Sydney on the Commercial Geography of Australia I felt a strong sympathy for the Jews in Egypt. For although I had not to make bricks without straw yet I experienced considerable difficulty as the 'straws' were so very much scattered and in many cases difficult to come at.

A student of Geography cannot help being struck by the wofully small bulk considered adequate for the treatment of Australia in a fairly up-to-date Geography. Canada and India, worthy jewels in the British Crown, may have several chapters devoted to them. Australia—certainly of equal commercial importance—is dismissed in a page or two. It is no uncommon thing to find an Atlas devoting full-page plates to Siam, Patagonia, Nova Scotia, &c., while the three States of Queensland, New South Wales, and Victoria—containing some of the largest towns in the Empire and some of the most important centres of industry in the world—are almost invariably grouped together in one small-scale map.

The present work is merely an *Introduction* to the study of the Commercial Geography of Australia. I have endeavoured to avoid bare statistics, and humbly following the plan of Mackinder, Davis, and other modern geographers, to lay the most stress on the physical controls which govern the industrial conditions in our Island Continent.

There has been no attempt to give an exhaustive account either of the physiographic or of the economic aspects of Australia. This would not be advisable for several reasons; but the main industries in each State, especially such as are characteristic of Australian environment, have been chosen for fuller treatment. In dealing with them their relation to Geology and Climate (more particularly to rainfall), is discussed, as well as their distribution. In a few cases some brief technological notes are added. A glance at the list of sections will show that some States must be more fully treated than others. New South Wales is most important for Wool and Coal; Queensland for Cattle and Sugar; Victoria for Irrigation problems; South Australia for Wheat, and so on.

I have endeavoured to acknowledge material borrowed from other works—almost wholly Government publications—in the text, but I am under great obligation to Professor David, F.R.S. (University of Sydney); to Mr. H. C. L. Anderson, M.A. (Intelligence Department, N.S.W.); Mr. R. Mackay (Public Works Department, N.S.W.), and Mr. D. J. Gordon of Adelaide, S.A. Especially do I wish to record my indebtedness to Dr. A. J. Herbertson, Professor of Geography in the University of Oxford.

T. G. T.

EMMANUEL COLLEGE, CAMBRIDGE,
May, 1910.

NOTE: *The final proofs have not been revised by the Author, who is on his way to the Antarctic as a member of Captain Scott's Expedition.*

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INTRODUCTION

In considering the industrial development of any area, there would seem to be three phases of growth in the progress of geographical knowledge.

(1) The first phase is the exploration and preliminary mapping of the continent. A glance at a series of maps, such as those of Australia shown in Fig. 2, shows the areas of unexplored land (here marked in black) shrinking year by year, until little or none remains. In the case of Australia isolated patches appear in Western Australia near the boundary of South Australia, crossed by the trails of the prospector and squatter in every direction. Although this lately explored area is in general a waterless region, yet near the more elevated tracts there are many acres of land suitable for pasturage. Present day explorations often aim at obtaining practicable stock routes to these better favoured regions, such as the MacDonnell Ranges, while government expeditions endeavour to open up feasible routes between isolated settlements, such as between Oodnadatta and Coolgardie, or Kimberley and Coolgardie.

As an example of such an expedition, take the arduous journey of Ernest Giles during 1875–6, when, starting from Port Augusta in South Australia, he crossed the Great Victoria Desert, passed just north of the site of Kalgoorlie and reached Perth. After a few weeks' rest, he returned eastward by way of Gibson's Desert, on a track 400 miles north of his previous journey, and reached the South Australian settlements again, fifteen months after his departure. To quote the *Year Book of Western Australia*, 'Giles was now able to thoroughly substantiate the views of those explorers and geographers who had described the *greater part of the interior of Australia* as a sandy desert, unfit for settlement.' Yet thirty years later flourishing towns exist in this desert, while Giles's route has been traversed by a solitary miner pushing a barrow before him! So much for the first stage.

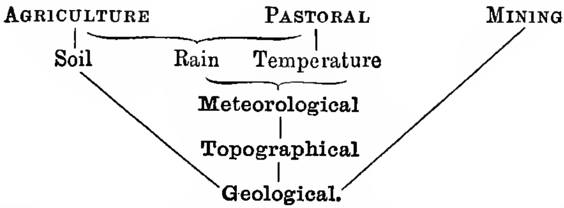
(2) The second phase in the development of geographical knowledge consists in the careful accumulation of statistics—chiefly by government departments—so that the secondary mapping of the several states is possible as far as regards railway routes, land occupation, geological, agricultural, and meteorological data. This necessarily follows the first phase—sometimes a long way behind it. The smaller and more thickly peopled states, especially Victoria and New South Wales, are very well supplied with such maps. The larger states whose resources are not yet fully known are rapidly filling in the blanks in their statistics.

(3) It is now possible to proceed to the third stage in the development of a country's economic geography, in which the data previously collected are examined as a whole from the geographical point of view and the broader features correlated. Such has been the work of Mackinder, Davis, and others in the older countries of the World, and in the succeeding chapters an attempt has been made to apply briefly, and for many reasons, inadequately, the methods so admirably employed in Britain, America, and elsewhere.

There would seem to be a definite sequence in this investigation. The physical factors controlling the industrial life of any country may be classed under three heads, topographical, meteorological, and geological respectively, and of these the last is not least. In a new country such as that under consideration, by far the greater proportion of the workers is directly concerned with pastoral, mining, and agricultural industries. Manufactures and transport do not bulk largely, as in the older centres, as means of livelihood.

It is unnecessary to emphasize the obvious relation between mining and geology, or between soils and geology. The local distribution of rainfall is closely bound up with topographical features, while these latter, as will be shown, are dependent on the arrangement of the geological formations.

The following diagram will perhaps serve to illustrate in a very broad sense the relation of these three main industries to the controlling factors mentioned above.



This diagram, while not to be taken too literally, indicates that the distribution of sheep and cattle is almost wholly a question of varying climate. Agriculture depends chiefly on soil and rainfall—since, given these, crops ranging from tropical to temperate can be grown in one area or another of the continent.

It also explains the order of treatment in the following chapters. The subject is dealt with in two parts, the first part being of a more general geographical character, and the second dealing with special industries in regard to their distribution, importance, physical control, &c.

In Part I, after a preliminary account of the discovery, exploration, and exploitation of Australia, the broad geological features are described with special reference to the topography of the continent. Then follows a discussion of the relation of contour and climate, with special reference to the question of rainfall. The systematic position of the Australian climates, among Herbertson's main types—a most important subject in connexion with the future development of industries—is treated next. The continent is next divided into five geographical units, and each of these (usually subdivided) is described in some detail with the aid of diagrams. By this means it is hoped that a clear idea of the inter-relation of the varied industries and their dependence on similar physical controls in any one region will be arrived at. The last section of Part I shows in greater detail the correlation of the geology and meteorology with the industrial development of one state—that of New South Wales.

In Part II, which deals with the great industries separately, the order is in the main determined by their relative importance. The Wool Industry, since wool constitutes one-third of the total exports of the Commonwealth, is described in the greater part of the first section: and closely allied to it are the Cattle and Frozen Meat industries. Artesian water—the use of which is almost wholly confined to pastoral areas—naturally finds a place in this section. The second section is concerned with the chief agricultural industry—that of wheat. Irrigation is a factor of great and increasing importance in the Wheat Belt and occupies a large part of this section. Section III deals firstly with metal mining, in which I have chosen to describe several of the most important ore deposits at some length rather than give inadequate descriptions of all the many important mines; and, secondly, with coal-mining. In Section IV four of the typical industries of Australia are considered—Timber, Sugar, Pearl-Shelling, and the Copra Industry of the South Seas. The last-named product is largely imported into Sydney, hence its somewhat arbitrary inclusion. Several of the lesser industries, such as wine-growing, are described briefly in the general geographical sections of Part I, and are therefore not specially mentioned in Part II. The subject of internal communication, whether by water or rail, is of great importance and is discussed in the next section. The last section of the book deals with future settlement in Australia, and is an endeavour to show in what areas industrial growth is likely to occur.

PART I

PHYSIOGRAPHIC ASPECTS

SECTION I. EXPLORATION AND EXPLOITATION

CHAPTER I

THE DISCOVERY, DIMENSIONS, EXPLORATION, AND EXPLOITATION OF AUSTRALIA

ALL who have studied the history of geographical discovery must have been struck with the wonderful voyages which took place during the last twenty years of the fifteenth century. The ocean paths to the West and to the East were traversed for the first time, and two continents, America and Africa, were represented on World maps. In 1487 Diaz reached the Great Fish River (near Port Elizabeth in Cape Colony); in 1492 Columbus reached the West Indies.

It is not too much to say that a great factor—possibly the greatest—militating against earlier exploration by Western peoples was the vast desert area, not only extending from Cape Bojador to Cape Verde, along the Atlantic, but occupying the shores of the Red Sea and reaching across Arabia (see Fig. 14). When the fertile lands (the 'Verdant' cape of the Portuguese) to the south of this barrier were discovered, exploration pushed on with rapid strides. It is of interest to note that a similar geographical factor tended to retard the exploitation of Australia for three hundred years. The NW. portion, being the nearest to Europe, was naturally that first discovered, and this is also largely a desert region. Even to-day the whole western half of the continent contains only seven per cent. of the population.

Probably most people have the idea that Cook discovered Australia—and this is true as far as regards its industrial capabilities—but the greater portion of its coast line had been accurately mapped long before 1770. According to some writers the same marvellous twenty years (1480–1500) of the fifteenth century first brought the third and last unknown continent to the knowledge of Europeans.

FIG. 1. Sketch-map showing the Progress of the Discovery of the Coasts; also the Relation of the fertile Dutch Indies to the barren NW. of Australia. Dotted areas over one person to 4 sq. miles.

Collingridge—who has investigated this question most fully—is of the opinion that seven years before Columbus set sail for America the west coast of Australia was indicated on charts. There is little doubt that the Arabs and other traders to the East Indies would know of the huge island to the south, and a map in the British Museum, dated 1489, shows a coast line in the latitude of Cape Colony and south of Malacca which is not present on earlier maps based on the travels of Marco Polo (A. D. 1300). Though this date of discovery, 1489, is based on somewhat slender evidence, there seems little doubt that a portion of the northern coast had been thoroughly explored by Europeans by 1536. Every bay and cape is named on the famous Dauphin map of this date. But Java la Grande—as it was called—offers few inducements to white settlement compared with other regions of Australia. In 1902 (cf. D. J. Gordon) there were less than 900 Europeans in Northern Territory, though Australia had long celebrated her centenary of settlement.

The Dutch supremacy in the East Indies dates from early in the seventeenth century, and in 1605 they explored the Gulf of Carpentaria and later (1616) the arid west coast near Sharks' Bay. In 1642 the first great voyage of Australian discovery—that of Tasman—resulted in the charting of the south coast, and had the Dutch maintained their supremacy in the East probably they would have founded settlements in the temperate lands they first discovered.

The English, led by Captain Cook, were the first to investigate the eastern coast of Australia. In April, 1770, Cook, the second great Australian voyager, sighted the mainland near Cape Howe and made a careful survey as far north as Cooktown. When Flinders and Bass discovered in 1798 that Tasmania was an island, the knowledge of the coastal configuration was practically completed.

It is interesting to note that some sixty-four of the eighty largest towns in Australia (i.e. those with more than 3,000 inhabitants) lie in the region whose coasts were discovered by the English.

This fact is indicated on the sketch-map and explains the main reason why neither the Portuguese, Spanish, nor Dutch made settlements on the Southern Continent. Moreover, these early navigators were traders rather than colonizers; though had the black occupants of the continent had even a rudimentary knowledge of trade and industry, probably their products would have found a market, and led to the founding of trading stations such as soon studded the East Indies.

After Cook's survey it was possible to gauge the size of the new continent, and some facts bearing on this question may now be given. Australia, including Tasmania, has an area of 2,974,600 square miles. It is interesting to note how similar is the area of the United States of America (2,970,230) which is 99·8% of that of the southern continent. Australia constitutes more than one quarter of the British Empire, and is nearly twenty-five times as large as the United Kingdom. 'It is this great size, taken together with the fact of the limited population (4,119,481 in December, 1906), that gives to the problems of Australian development their unique character.'[1] It extends through 33° of latitude, which is equal to a journey from London to Cape Verde, so that it is obvious that one cannot strictly speak of the *climate* of Australia, for it has many climates, ranging from a tropical climate akin to that of the Sudan to a cool temperature like that of Scotland.

In position it is more isolated than any other large land mass. Taking as a standard of length the distance from London to Algiers (about a thousand miles), the journey from Perth to Colombo is more than three times this unit; and the same huge distance lies between Hong Kong and Thursday Island in the north of Queensland. Indeed, Java is the only large civilized area which is within a thousand miles of any portion of Australia. But Australia itself is a country of vast distances. The two capitals Perth and Adelaide are some 1,600 miles apart, while to reach Broken Hill—the third town in New South Wales—from the capital Sydney, a railway journey of some 1,400 miles (via Melbourne and Adelaide) is necessary.

[1] G. H. Knibbs, *Commonwealth Year Book*, 1908, p. 57.

The exploration of the Interior of Australia until 1860 was carried out almost wholly with an eye to the main chance, and a brief survey of the order in which the various areas were occupied forms a good introduction to the succeeding chapters.

In 1788 Phillip landed at Botany Bay from the 'First Fleet', but soon discovered the immeasurably superior site of Port Jackson, some eight miles to the north. To this day the northern and southern shores of Botany Bay have remained almost deserted except for glue-works, boiling-down and wool-scouring plants, and other more or less unsavoury industries.

The earliest settlement, consisting largely of most unprofitable members, was subjected to many trials, and in the first year of the nineteenth century (1801) numbered only 5,547 persons. Agriculture did not thrive near Sydney in the sandy soil, and though good soil was found near Parramatta (15 miles to the west) the area to the east of the Blue Mountain Scarp was soon found to be too restricted for the multiplying flocks and herds of the settlers. Yet it was twenty-five years before Blaxland's party managed to climb the rugged slopes of the Blue Mountains, and found the ideal pastoral country at the head of the Macquarie. From this time (1813) the rise of a huge Pastoral Industry was assured, and exploration in Australia has largely consisted of 'treks' to find new pastures.

The early exploration of Australia is full of interest to the student of economics. The feeling that 'better lay beyond' was shared by every pioneer until 1873-6, when by the crossing of the unknown desert by Warburton, Forrest, and Giles, the limits of the possible pastoral areas of Australia could be determined with some accuracy.

Very early the explorers found that the rivers of the inland portion of New South Wales all seemed to flow towards the west, and therefore we find Hume hailing Lake George (near Goulburn, N. S. W.) as a portion of an inland sea, and Mitchell carrying boats over the Western Plains to navigate this hypothetical sea. In February, 1830, Sturt

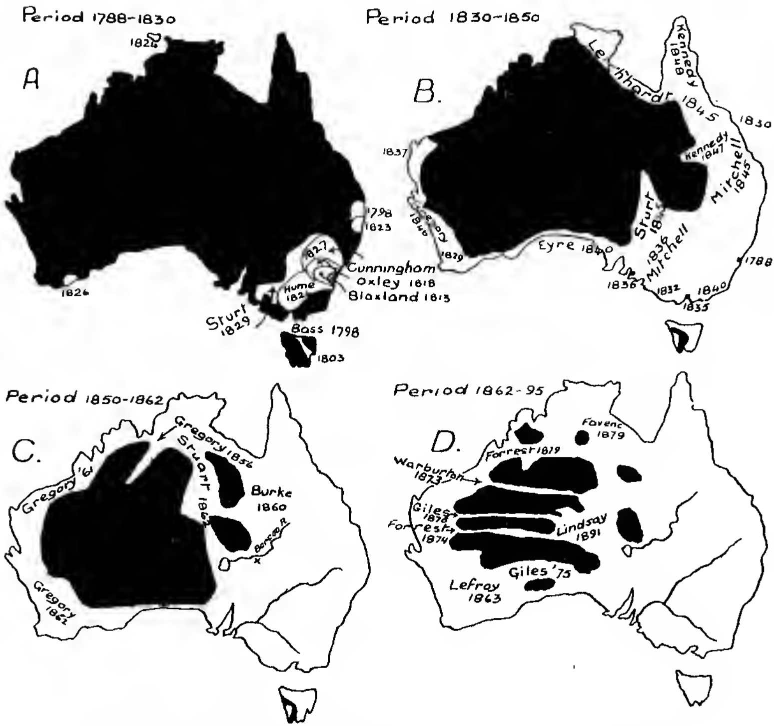


Fig. 2. Progress of the Exploration of the Interior of Australia.

had found the Murray mouth and had commenced his attack on the desert which always baffled him, for he had penetrated but a little by 1845 (see Fig. 2 b). Mitchell, during this period, was more fortunate, and discovered the fertile Western Plains of Victoria and the good pastoral country in Southern Queensland. The unfortunate explorers Leichhardt and Kennedy opened up the north-east of Australia, though here, if the desert were absent, the blacks were more numerous and dangerous than in the south. Eyre and Gregory had explored the south and west, but except in the Perth-Albany area there was no incentive to any but a pastoral settlement, moreover here the desert approached much nearer to the coast.

1850 marks the close of an almost wholly pastoral Australia. True the Burra mines north of Adelaide yielded rich copper ore in 1844, but they were of little importance compared with the vast mineral output which followed the gold discoveries of 1851 in the Bathurst district (N. S. W.) and of 1852 around Ballarat in Victoria. Unlike the later metalliferous discoveries of Broken Hill and Coolgardie, these fields were developed in country which had been occupied by sheep stations for years, so that they had no direct effect on the exploration of Australia.

During the period 1856-62 the Gregorys found new pastoral areas all round the north and west of the Great Desert, while A. C. Gregory on the north penetrated to the desolation of spinifex and sand in which Stuart's Creek loses itself (see Fig. 2 C).

In the seventies no less than five expeditions crossed the great desert. Warburton (1873), J. Forrest (1874); Giles, to the south (1875), returned through the centre in 1876, and A. Forrest across the north in 1879 (see map, Fig. 2 D). All found the same waterless region which is described in some detail in another section (pages 109–14).

In 1860 began a new phase in this exploration. Stuart from Adelaide and Burke and Wills from Melbourne were spurred onward very largely by the desire to be the first to cross Australia from South to North. They both succeeded, but while the costly and ill-managed expedition of Burke and Wills resulted in the death of the leaders near the Barcoo River (at ×, Fig. 2 c), that led by Stuart was very successful and resulted in the discovery of fair pastoral land around the MacDonnell Ranges in the heart of the continent. Moreover his route formed a preliminary survey for the overland telegraph (completed in 1872) which extends 1,973 miles from Adelaide to Palmerston.

In 1883 gold was first discovered in Western Australia, in the Kimberley district, and the ensuing 'prospecting' resulted in the exploration of much new country. In 1892 the Coolgardie fields were found well within the desert country and several[1] prospecting expeditions (such as Carnegie's, 1896) have practically erased the unexplored patches from the map.

The Horn expedition, of a scientific character, to the MacDonnell Ranges in 1894 marks a new development (see p. 114), while Calvert's in 1896 (under Wells), though marred by the death of several members, was primarily undertaken for the purpose of mapping the remaining unexplored regions.

In conclusion let us glance at the history of the Industrial expansion of Australia during the last fifty years.

In 1906 the principal exports were approximately as follows:—

	£		£
1. Wool	22,600,000	9. Frozen meats	1,500,000
2. Gold	14,600,000	10. Sheep skins	1,500,000
3. Wheat	9,700,000	11. Timber	1,000,000
4. Silver-lead	3,600,000	12. Tallow	876,000
5. Butter	3,300,000	13. Rabbits	486,000
6. Copper	3,300,000	14. Pearl shell	120,000
7. Coal	2,000,000	15. Wines	100,000
8. Tin	1,500,000		

In 1788 Captain Phillip brought out twenty-nine sheep and six cattle, and these had increased (with fresh imports)

[1] The routes of some of these later expeditions are shown on the sketch-map of the Great Plateau Region, Fig. 27, p. 104.

to sixteen million sheep and two million cattle in 1850. By this time (compare Fig. 2 B with Fig. 33), the best *sheep* country had been occupied and comparatively few flocks now range in areas discovered since that date; though the best *cattle* districts lie in the more northern belt explored from 1850 to 1860.

Very early in the continent's history the value of the coal was appreciated. It was discovered both north and south of Sydney (near Newcastle and Bulli) in 1797, and in 1850 the coal raised was worth £23,000. In ten years the value had jumped up to £226,000, of which two-thirds was received for exported material.

Two important industries became prominent in South Australia about 1842. They were wheat-growing and copper-mining. For years South Australia was renowned for these commodities. Now it is only the fourth among the copper-producing states. Queensland is first, the erstwhile gold mine of Mt. Morgan being her most important source, and Tasmania with Mt. Lyell (1886) is a close second. In wheat also, New South Wales and Victoria with their greater area of wheat lands have outstripped South Australia, though it was not till 1898 that New South Wales exported wheat, while in 1903 a large import was necessary owing to the drought.

In 1851 Hargreaves discovered gold near Bathurst, N.S.W., and gold areas have gradually been exploited in districts all round the Artesian and Murray Basins—whose sediments are too recently deposited to be auriferous.

During the fifties and sixties the south-east highlands were extensively prospected from Ballarat to Gladstone in Queensland. In the early seventies gold was found in Northern Territory, and at Palmer River and Charters Towers in North Queensland. The rich 'deep leads' of Gulgong, near Bathurst, were discovered in 1871. During the eighties Western Australia was found to have large areas of auriferous country, which were traced into the arid interior from 1890 to 1898. Two isolated gold-fields in the South Australian desert (Tarcoola, 1893, and Arltunga, 1902) show that there is no reason to despair of the discoveries of further 'Kalgoorlies'.

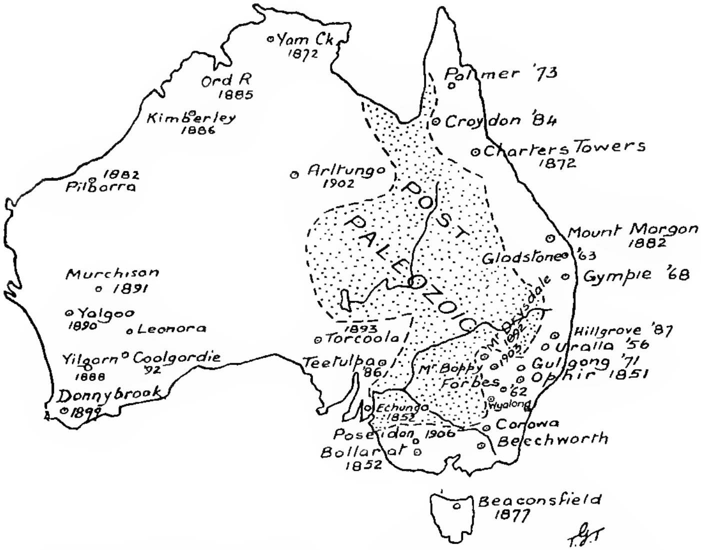


FIG. 3. Dates of Gold Discovery. Non-auriferous formations dotted.

It is by no means only in the desert that rich finds are now being made. Wyalong and Mt. Boppy (near Cobar), two of the richest fields in New South Wales, date from the nineties, while Poseidon (1906) seems to show that all the 'Welcome Nuggets' have not yet been gathered from the Ballarat area.

The next important product on the list of exports is Silver-lead. Broken Hill (1883) contributes 78 per cent.

and Mt. Zeehan (Tasmania, 1885) 15 per cent. of the total for Australia, so that these two centres account for more than 90 per cent. of the whole. Lead, *per se,* is not mined in Australia, the silver present in the argentiferous galena being in most cases the chief desideratum.

The fourth in order of importance of the metals exported is tin. One of the richest mines in the world is situated near Mt. Bischoff in the jungles of North-West Tasmania and was discovered in 1871. It is still producing much tin and gives Tasmania a slight advantage over Queensland. Tin mining on the mainland dates from 1872, when rich mines were discovered near the New South Wales border at Inverell and in Queensland, near Warwick. Later deposits have been found near Beechworth (Victoria), at Herberton (near Cairns, Queensland, 1879), and in West Australia (about 1890) at Greenbushes and Pilbarra.[1]

In the last twenty years three thriving industries—which were not dreamt of in the earlier days of industrial occupation—have become of great importance. Butter was first exported from New South Wales in 1890, and in 1904 fifty million pounds (weight) were produced, some twenty millions being exported. Frozen meat (mutton and beef) was shipped to England in 1881 from New South Wales, and is now ninth on the list of exports. Finally, a credit side is placed to the account of the rabbits. In New South Wales alone rabbit-proof fencing to the extent of 45,000 miles has been erected, costing £2,500,000, but it would seem that in the course of time the trade in frozen rabbits, &c., which was worth £500,000 in 1906, will counterbalance the damage done by them.

[1] These mining fields are shown on the sketch-maps of the chief geographical regions, Figs. 18–27.

SECTION II. PHYSICAL CONDITIONS OF AUSTRALIA

CHAPTER II

THE RELATION OF TOPOGRAPHY TO GEOLOGY

AUSTRALIA is somewhat oval in shape, with two well-defined breaks in the outline, the Gulf of Carpentaria on the north, and the Australian Bight on the south. A diagram showing approximately the main contours of Australia is given in Fig. 4, and shows that the continent is strikingly devoid of strong contrast. Three-quarters of the land-mass lies between the 600 and 1,500-feet contours in the form of a huge plateau. Of the remainder there is a low-lying area comprising the Murray and Lake Eyre Basins, partly separated by the Flinders and Barrier Ranges; and secondly, a fringe of land with an elevation of two or three thousand feet—culminating in 7,000 feet at Mt. Kosciusko—extending through Victoria, Eastern New South Wales, and Eastern Queensland. Isolated elevated areas, such as the MacDonnell and Musgrave Ranges in Central Australia, and others in Ashburton, Kimberley, and Arnhem Land reach three or four thousand feet but are usually of the nature of bulges on the surface of the plateau rather than true mountain ranges.

We can readily distinguish the five main topographic divisions of the continent. There is the elevated Cordillera extending from Cape York along the east coast to the Murray Mouth; the huge Western Plateau; and the low-lying basin of the Murray-Darling system separated from the Lake Eyre Basin by the long ridge of the Flinders Range.[1]

Can these be correlated with the geological structure of Australia? Undoubtedly.

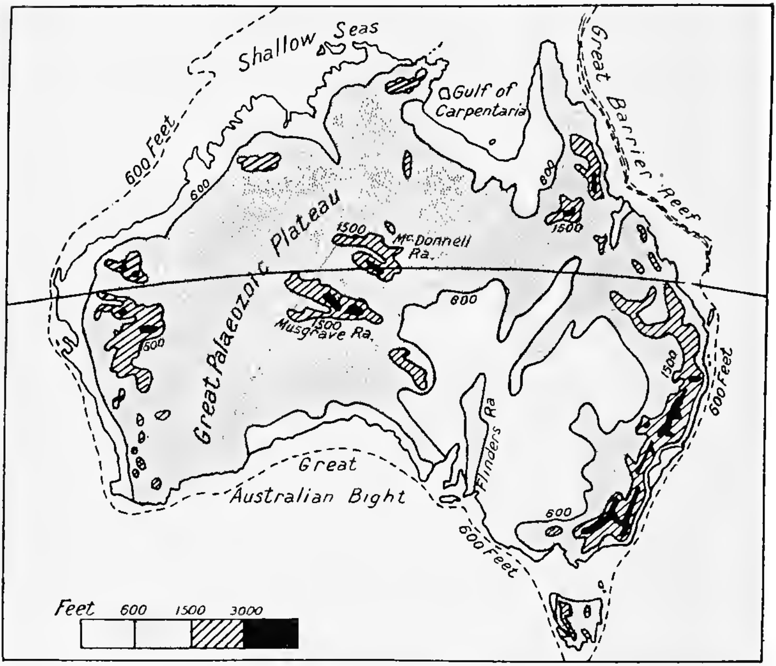


Fig. 4. Contour Map of Australia.

In Australia, as in other parts of the World, the periods at which rocks were deposited are determined by their fossil contents. For the purposes of this section only the three main terms, tertiary (or Cainozoic), secondary (or Mesozoic), and primary (or Palaeozoic) will need to be remembered.

[1] These five divisions are defined and sketched in chapters vii–xi.

Rocks deposited during the last few million years contain fossils on the whole closely resembling living forms. They have been termed *tertiary* sediments. Passing back in geological time we get a series of rocks characterized by remains of huge reptiles and other animals to which only a few rare living genera are in any way akin. These rocks belong to the *secondary* age. Earlier again we have an immense succession of strata stretching back through millions of years to the dawn of life. These are known as rocks of the *primary* age.[1]

In Fig. 5 an attempt is made to show the broader geological features of Australia. No complete map has been issued for the very sufficient reason that Central Australia is largely a 'terra incognita' as far as its geology is concerned.

Undoubtedly the dominant feature is the vast area of *metamorphic* rocks in the west. These are highly altered rocks, originally both sedimentary and eruptive, which have lost all, or almost all, semblance of their original form through crushing, folding, and chemical action. Such rocks as *schists*, gneisses, and altered slates, together with granites and basic rocks—termed *greenstones* for want of a better name—are common. This solid 'massif' has endured from the dawn of life, resisting later folding, and

[1] The generally accepted subdivisions of these are:—

		No. on Map 5.
Tertiary or *Cainozoic*		7 and 8
Secondary or *Mesozoic*	Cretaceous	6
	Jurassic	
	Triassic	
Primary or *Palaeozoic*	Permian	5
	Carboniferous	4
	Devonian	
	Silurian	3
	Cambrian	2
Eruptive or Igneous	Granites, &c.	
Metamorphic or Altered	Schists, &c.	1

has been gradually worn down to a huge plateau of some 1,500 feet elevation. The remarkably rich gold deposits of Western Australia occur in these rocks. Their geology will be briefly discussed later. This ancient area is shown

FIG. 5. Geological Sketch-map of Australia, with a generalized Section from Perth to Sydney. 1 = Gneisses and Granites (Archean); 2 = Cambrian Sediments; 3 = Silurian Slates, &c.; 4 = Devonian and Carboniferous; 5 = Coal-measures (Permian, &c.); 6 = Cretaceous Artesian Basin; 7, 8 = Tertiary; 9 = Pleistocene Coral Limestone.

by the curved lines (1) in Fig. 5. Fringing it are areas of newer rocks deposited in bygone gulfs and then elevated above sea-level.

Secondly, we come to rocks (2, Fig. 5) which are immeasurably old, but containing fossils representing the earliest forms of animal life. A large area occurs in South Australia, constituting the Flinders Range. It may extend to New South Wales. These rocks are surrounded on all sides by sediments of a comparatively recent date, geologically speaking (see 6, 7, and 8, Fig. 5). The former sediments (2) contain numerous copper mines (Moonta, Burra, &c.) and are thought by some geologists to extend to Broken Hill, and thus form the matrix for the largest Australian ore deposit.

Thirdly, a large series of slates and sandstones (3) are most fully developed in the south-east of the continent, but found also over large areas in Queensland. They may be classed as middle palaeozoic (silurian and devonian). They have been subjected to great folding forces, which have buckled them into ridges and troughs.

Fourthly, somewhat later there were deposited huge masses of rock which have been similarly folded in Queensland (4) and New South Wales.

These buckled and warped rocks have been in touch with hot underground waters. This explains the prevalence of valuable metalliferous reefs such as the gold-bearing Saddle Reefs of Bendigo, the auriferous reefs of Ballarat, the copper deposits of Cobar, the tin of Chillagoe and New England. In fact almost all the reefs of Eastern Australia occur in rocks of palaeozoic age.

The *fifth* group of rocks (5) are those bearing valuable coal-seams and hence known as coal-measures. It is sufficient to state here—as the matter will be discussed in a later section—that the coal-measures lie in huge troughs formed by the folding or erosion of the earlier palaeozoic rocks. Though of several ages, all the best seams belong either to the late palaeozoic (permo-carboniferous) or early mesozoic (triassic).

The *sixth* area is the huge Artesian Basin (6), extending from the Gulf of Carpentaria almost to the South Australian gulfs. It is by far the most extensive formation which has been adequately mapped in Australia and is of great economic importance. In its relation to stock routes and irrigation it forms the subject of a separate section.

In the *seventh* section are grouped the tertiary and recent rocks. They comprise large areas of sediments due to the action of existing rivers, as in the Gulf Country in Queensland, and to the latest movements of elevation in Australia, which have raised marine sediments into dry land, especially around the Murray Mouth (see Fig. 23). Other areas of new land—speaking in a geological sense—are found in Nullarbor Plains (near the Australian Bight) and Barclay Tableland (7 and 8 in the map, Fig. 5).

Lastly, one of the most interesting areas of recent land-growth in the World may be mentioned—the coral rock gradually spreading over the sinking Queensland continental shelf. This huge deposit of limestone extends for 1,250 miles and has an average width of 35 miles along that distance. Many important industries have arisen in connexion with this formation, such as pearl-shelling, bêche-de-mer fishery, turtle-fishing, &c. It is also of great commercial importance as constituting what may be termed a marine 'Grand Canal' largely used in Australian trade with India and the Far East.

Having thus summarized the broad topographical and geological features, an interesting correlation expressed in the table on pages 32 and 33 may be made.

From the following table it will be seen how closely the topographical divisions coincide with the geological structure of the continent. Traversing Australia from east to west along the section below Fig. 5, we see that the highest land consists of palaeozoic rocks (3)—by no means, however, the oldest sediments represented—buttressed by granite, as at

Kosciusko and New England. As soon as the low-lying belt, extending from the Gulf of Carpentaria to the Murray Mouth, is reached, a very much newer formation—late mesozoic or tertiary (8) is encountered. Crossing the southern portion of this lowland we reach the very ancient limestones (2) and slates of the Flinders Range which are of cambrian (i.e. oldest palaeozoic) age.

The west of the continent consists very largely of altered rocks (1) which seem to have formed a land-mass since very early times, and in which few fossiliferous beds occur. They apparently are the worn-down bases of a much greater elevation, but their geology is not yet worked out. Around the Australian Bight is an area of late sediment (7), provisionally classed as tertiary, and on the west coast there is a fringe of palaeozoic (5) and later sediments, somewhat resembling—but not so extensive as—those on the east.

Group.	*Geological Formation.*	*Topography.*	*Climate.*	*Economic Value.*
A.	*Metamorphic Rocks* of West A. and N. Territory; schists and slates, probably pre-Cambrian in age. Granites and greenstones.	A Plateau of some 1,000 feet elevation. No high mountains and no rivers except along the coast.	Situated in the Trade Winds area along the tropic of Capricorn. Hence very dry, with few important ranges to condense erratic cyclonic rain clouds.	Largely desert, little agricultural value. Many valuable mineral deposits, e.g. Coolgardie, Murchison and Kimberley Gold-fields.
B.	*Older Primary Rocks.* Cambrian (2), silurian, (3), devonian, carboniferous (4). Usually crumpled, faulted, and penetrated by intrusive rocks. N.B. Probably the main folding occurred in carboniferous time.	Form the backbone of Eastern Australia; Flinders Range, S. A.—Victorian Highlands, Snowy Mountains, and the Great Dividing Range in general. Their flanks are covered by later sediments.	Favourably situated to condense the moisture of sea-breezes, cyclones, SE. trades and other winds. Hence the rainfall is heaviest in this belt.	The chief metalliferous deposits, except those noted above, occur in these crumpled strata. In the valleys and coastal regions of this group the main population of Australia dwells.

Group.	*Geological Formation.*	*Topography.*	*Climate.*	*Economic Value.*
C.	*Coal-bearing strata* (chiefly permo-carboniferous and triassic) (5). Sandstones and shales with numerous coal seams. Occupy basins (geosynclines) in the preceding rocks.	Forming an integral part of Section B. In some cases the softer coal measures have been eroded to a greater extent than the rocks enclosing the basin, as in the Hunter Valley, N. S. W.	Too small in area to affect the main features. Yet the coal strata have undoubtedly indirectly affected the rainfall in a few localities (see p. 122).	The manufacturing industries, more important potentially than actually at present, will develop along the great coal basin of Eastern Australia.
D.	*Newer sediments* which, in the main, have not been folded or crumpled. Includes the great artesian basin and tertiary deposits of Eastern Australia.	The Great Central Plain of Australia. Low-lying country, extending from the Gulf of Carpentaria to the Great Australian Bight. Few large rivers, nearly dry in summer.	Eastern portion dry, but with a fair rainfall owing to proximity to mountains and the coast. Western portion merging into desert.	The east is the great grazing country of Australia. The west is watered sparsely by Artesian wells. Opals are practically the only mineral wealth, except alluvials associated with palaeozoic rocks.

CHAPTER III

FACTORS GOVERNING THE CLIMATES OF THE SOUTHERN HEMISPHERE[1]

For an intelligent grasp of the Economic Geography of a large area like Australia it is essential to study carefully the physical conditions which control the life and industry of the continent. Of these physical controls those of climate and geology are of paramount importance. Quoting a well-known writer, 'Large commercial relations can exist only between large populations, and these are found in those temperate or tropical regions that are best adapted to support human life. Unfavourable climates have small populations and little commerce; no large industries except mining can thrive where climate does not permit large agriculture or animal-raising.'

Hence the problem of commercial supply is based very largely on a study of climatic conditions, and it will be our endeavour to explain in some degree the little-known and rather vexed question of the factors governing the climates of Australia.

In the first place it will readily be recognized that an area of land extending from 10° to 45° of latitude will embrace a variety of climates. Indeed Port Darwin in the extreme north has a hot, moist climate like that of Trinidad (West Indies), while the climate of Tasmania has often been compared to that of England. To understand clearly, therefore, the various conditions governing this vast area it is well to study the meteorology of the

[1] The writer is indebted to Professors David and Herbertson for suggestions both as to treatment and matter in this section.

belts of the southern hemisphere on the equatorial side of 45° S.

We may begin by deducing in logical sequence, *first*, what would be the climatic phenomena on a *stationary* uniform globe enclosed in a shell of air; *secondly*, the effect of the rotation of the Earth from west to east on such a system; *thirdly*, the seasonal changes brought about by the revolution of the Earth round the Sun; and *fourthly*, the variations arising from the somewhat complex distribution of land and sea on our globe.

One might reasonably expect to observe the following phenomena on a *stationary globe*. At the equator the atmospheric layer is heated strongly and expands. It is therefore lighter than a corresponding bulk of the colder air beyond, and the latter flows in along the surface from north and south. The warm air is therefore displaced upwards, forming a belt of relatively low pressure at the surface all along the equatorial belt. From this belt the upper portions of relatively high pressure continually stream polewards and thus the primary circulation of the air arises; a surface wind blowing *to* the equator, and an elevated wind blowing *from* the equator (see Fig. 6).

Consider the path of this *elevated* air-current in tropical regions. There seems little reason to doubt that it is concerned in the production of the belt of high pressure which is so definite a feature of the southern hemisphere between latitudes 25° and 35°. Various hypotheses have been suggested, of which the following is plausible. It is supposed that the elevated air-current flowing towards the South Pole becomes chilled as it gets into colder latitudes, and so tends to sink to the surface. Moreover the fact that the width between any two meridians (see Fig. 6) becomes less as the poles are approached perhaps leads to a compression of the air-currents, and so an increase of pressure may arise; much as the pressure is increased when water is forced through a narrow channel. Whatever be the reason the fact remains that a belt of high pressure occupies the 30th parallel, or thereabouts, for the greater part of the year, and the above considerations—which would also apply to a rotating earth—may be of assistance to the reader in connexion with this difficult question.

To the south of the Equatorial Low Pressure Belt and within this High Pressure Belt, near the tropics (23½°) occurs a neutral zone of calms, which is of immense

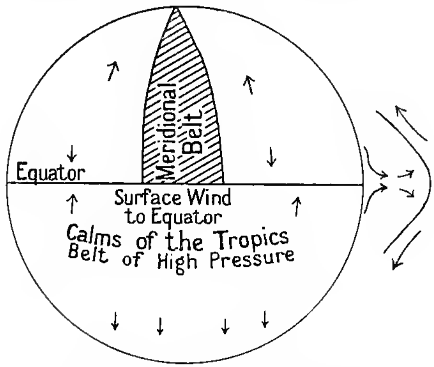


Fig. 6. Atmospheric Circulation on a Stationary Globe.

importance in connexion with the question of environment (see Fig. 6). This point is discussed later.

No countries in the southern hemisphere of commercial importance lie far beyond the High Pressure Belt, so that it is unnecessary to consider the meteorology of high latitudes.

The rotation of the Earth has a profound effect on this comparatively simple circulation. We know that each point on the equator is moving from west to east with a velocity approaching eighteen miles a minute. The velocity decreases towards the poles, where it is zero.

Without entering deeply into the dynamics of the question, one can readily understand that there will be a considerable distortion impressed on the path of any object moving along a meridian.

This deflection due to the Earth's rotation has been mathematically investigated by Ferrel and others, who deduce the general law that all bodies (including air) moving *in any direction* in the *southern* hemisphere have a tendency to be deflected to the left.

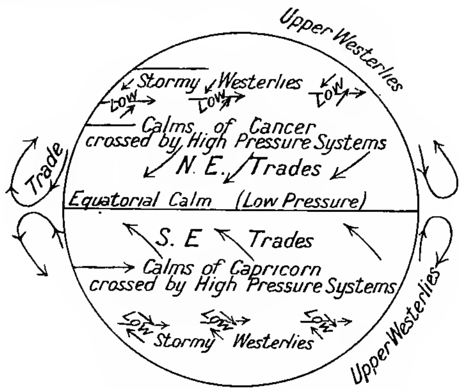


FIG. 7. Atmospheric Circulation on a Rotating Globe.

We must therefore modify the wind directions shown in Fig. 6, the more correct paths being shown in Fig. 7. The elevated poleward wind (counter- or return-trade) is so much modified by the rotation factor that on reaching the surface it has practically become a westerly wind.[1] The

[1] A simple dynamical example may make this clearer. A stone thrown in a southerly direction from an east-bound express train is deflected with respect to the (relatively slow-moving) earth and can be compared to the air in the southern anti-trade winds. The stone, to an onlooker, would appear to come from the north-west. In a similar manner the original return-trade is converted into a westerly wind.

two winds named in the figure—the *south-east trades* between the equator and the tropic of Capricorn, and the *westerlies* of 40° S. latitude (Roaring Forties)—are the prevalent winds in those regions of the southern hemisphere.

Before considering the *effect* of the distribution of land and sea on the atmospheric circulation of the southern hemisphere, it will obviously be an advantage if we can

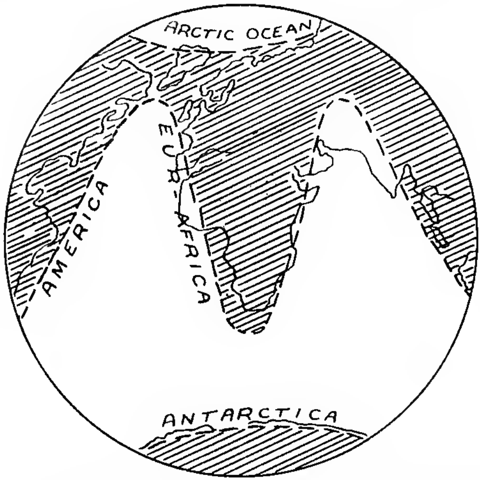


FIG. 8. The Symmetrical Earth-plan. (Based on Lowthian-Green and others.)

discern any 'design' in the relative positions of land and sea. A reference to Fig. 8 will show that there is some such design, which Professor J. W. Gregory has termed the Antipodal arrangement.

It will be seen that the circular Arctic sea is opposite the circular Antarctic continent, and that the three great oceans (Atlantic, Indian, and Pacific) approximately alternate with the continental masses of Eur-Africa, Asia-Australia, and America.

Dividing the Earth's surface into isothermal zones according to Supan's plan—where 32° F. and 68° F. for the coldest month, and mean annual temperature, respectively, are chosen as the significant temperatures (see Fig. 9)—we get five zones on each side of the equator. The following table shows approximately the land-areas in square miles (from Blackie's Atlas).

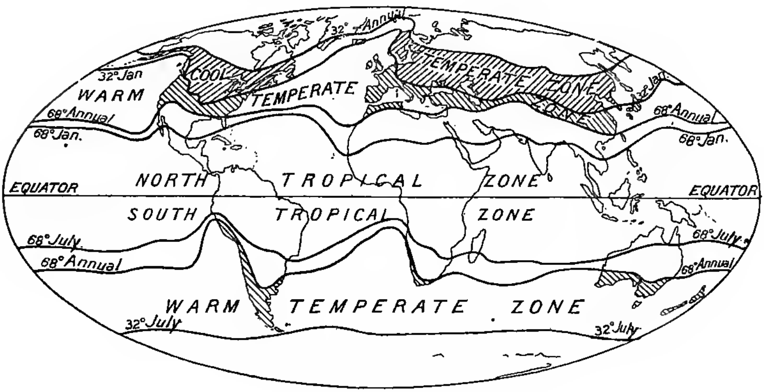


FIG. 9. Thermal Zones.

No.	*Zone.*	*Northern Lands.*	*Southern Lands.*
1.	Frigid	7 million sq. m.	None of economic importance
2.	Cool temperate	10 million ,,	,,
3.	Warm temperate	4½ million ,,	2 million sq. m.
4.	Semi-tropical	8 million ,,	4 million ,,
5.	Tropical	7½ million ,,	6 million ,,

Whatever be the value of this deduction with regard to the origin of the Earth's surface-features[1] there is no doubt

[1] This subject and its bearing on the 'Plan of the Earth and its Causes' is discussed by J. W. Gregory in the *Geographical Journal*, 1899, vol. xiii, p. 225.

that it is very helpful in discussing various aspects of Austral Meteorology, such as the eddies in the Great Belt of Southern Anticylones (see page 43) or the correlation of Climatic Regions (page 59). Moreover, as the southern hemisphere contains the *oceanic* belt in this Antipodal arrangement, it follows that the lands capable of commercial development are much smaller south of the equator than in the northern hemisphere.

The zones 2 and 3 may fairly be said to contain all the great manufacturing interests in the world, and to be the most favourable for white colonization. In the northern Hemisphere these comprise nearly fifteen million square miles, in the southern hemisphere only two million lie within the favoured region.

Having now emphasized the peninsular or insular character of the southern lands, the discussion of their meteorology may be resumed.

The winds of the southern hemisphere obey simpler laws of circulation than do those of the northern hemisphere. This is due to the fact that the southern hemisphere offers much less *irregularity of surface*, consisting for the most part of large ocean areas.

Want of space forbids more than a brief account of the way in which the distribution of land and water modifies the atmospheric conditions of the surface of the southern hemisphere, and more particularly of Australia.

The enormous land-bulk of central Asia exerts a strong influence on the northern portion of Australia. During July (the northern summer) the hot air rising over southern and eastern Asia draws in surface supplies from the south and undoubtedly reinforces the south-east trades in northern Queensland. During the four months of the southern summer the south-east trade is replaced by variable winds in this region.

During December (the southern summer) the centre of Australia becomes strongly heated and the cooler air from the north flows in (being heavier than that in Australia) and may be imagined as displacing the lighter medium, much as mercury displaces water. Actually no great bodily transfer takes place, the temperature-change being effected largely by conduction and convection currents.

As will be explained in the section on Australian rainfall, these monsoonal winds from the north are the chief rain-bringers of north and Central Australia. That portion of Australia lying in the temperate zone (by far the most important industrially) is, however, dominated by a series of huge eddies in the atmosphere, gradually moving to the east, which are known as the anticyclones.

Let us consider the path of the return-trades once more, as shown in Fig. 7. There are several outstanding facts on which to base our hypotheses. At the equator the ascending air must flow poleward, as explained previously. At latitude 40° S., ('the roaring forties,') a very constant wind blows from the west and is known as the 'Brave West Wind'. Between these two belts we have a zone in which the surface air moves as a system of great whirls, while the whole moves bodily to the west. Finally, observations have shown that at considerable elevations above sea-level in New South Wales a fairly constant westerly wind is blowing which may be in a contrary direction to that experienced below. This has been shown by balloon flights, and by the records of the Mt. Kosciusko Observatory at an altitude of 7,000 feet. There would therefore seem to be some foundation for the theory that the 'Brave West Winds' are practically continuous with portions of the counter-trades, which, starting from the equator as a northerly wind, veer round to the left to such an extent that at latitude 40° S. they have become Westerlies.

Between latitudes 20° and 40° we may postulate, therefore, a broad belt of air at an elevation of several thousand feet always blowing from west to east. A glance at a globe or map will show that this belt lies over the most open expanse of the Earth's surface. In fact, only three obstructions occur in its path. They are the three southern apices of the land triangles discussed previously; namely the Southern Andes, the Drakensbergen, and the Eastern Highlands of Australia.

What happens in a river, when rock-bars cross its bed? The water near the obstructions is thrown into a series of more or less permanent eddies which have a constant rotational movement together with a gradual movement down-stream.

There is a somewhat similar set of conditions in the Earth's atmosphere along the high-pressure belt between 20° and 40° south latitude. We may compare the *elevated* westerly drift to the main body of the river in our illustration. The lower layers of the atmosphere—beneath this westerly current—are penned in, as it were, between the 'rock-bars' of the Andes, Drakensbergen, and the Eastern Highlands of Australia. These lower strata of air are, however, dragged to the east and form a series of majestic eddies which are known as Anticyclones. Each travels across Australia in somewhat more than a week, there being about forty-five in the year, and they exert a dominant influence on the weather of the continent. The damming-back of the anticyclones by the mountain ranges would seem to be demonstrated in New South Wales. Indeed, there appears to have been a definite deflection of the eddies to the north on some occasions whereby the anticyclone passes through the comparatively

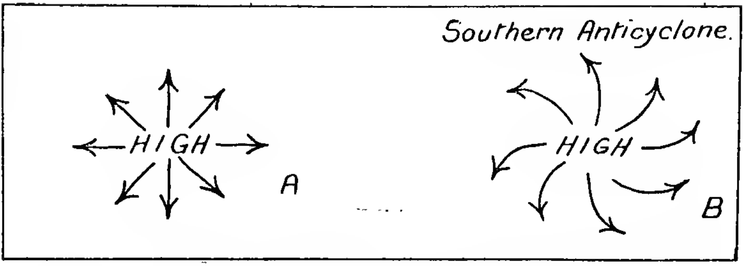


FIG. 10. Showing how the Air-currents from an Area of High Pressure (Anticyclone) in the Southern Hemisphere tend to change into a counter-clockwise Eddy.

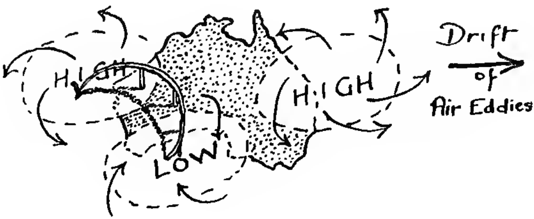


FIG. 11. Diagram showing the Passage of Air Eddies (Anticyclones or HIGHS and Cyclones or LOWS) across Australia. The small arrows show surface winds. The large arrow represents the elevated air-current passing up the centre of the LOW and descending in the centre of the HIGH.

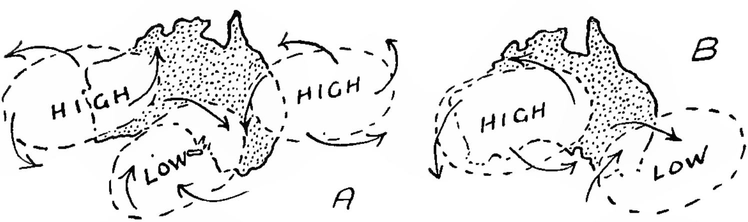


FIG. 12. Two Weather Charts, *B* being a few days later than *A*, showing Conditions favourable for Rain along the Murray River in *A*. In *B* dryer weather may be expected in that region. (See p. 52.)

low gap (at the head of the Hunter River system) to the Pacific.[1]

The eddies constituting the high-pressure belt in the southern hemisphere have been whimsically compared to a string of sausages encircling the earth near latitude 35° S., each having an area somewhat less than that of Australia and moving about 400 miles a day towards the east. Farther to the south the eddies are not so pronounced and the open belt along latitude 45° S. is traversed (at sea-level) by what are perhaps the most permanent winds on the Earth, the stormy westerlies.

In the high-pressure eddies or anticyclones, the air-currents have a definite path. Around such an area of high pressure, the air tends to blow away from the centre. But the rotational factor (vide page 37) imposes a left-hand component so that instead of the arrangement sketched in *A*, Fig. 10, we get the *swirl* illustrated at *B*. So that the winds in the southern hemisphere blow in a *counter-clockwise* direction around an area of high pressure.

In these anticyclones the dense air flowing away at the surface from the *high* (as the high-pressure area is termed) is replaced by more air flowing in from the upper regions at the centre. This supply is maintained by an accompanying low-pressure eddy of the converse type (a *cyclone*), usually moving along to the north or south of the Anti-cyclone Belt. In the cyclone the currents flow inwards along the surface and rise at the centre to colder regions (see Fig. 11).

[1] This relation of anticyclonic movement to the Great Dividing Range is discussed briefly in a paper by the writer in the *Proceedings of the Linnean Society of New South Wales*, 1906, vol. 31, p. 525.

CHAPTER IV

THE RAINFALL OF AUSTRALIA

There is a loose phrase much used by rain-prophets and others to the effect that 'mountains attract the rain'. They have noted the fact that in general mountains are wetter than lowlands; but as the explanation is by no means obvious it will be well to explain briefly why the wetter regions of Australia are so closely correlated with the highlands of the continent. It depends essentially on a simple physical relation between water-vapour and the atmosphere.

A cubic foot of air will carry eleven grains of water-vapour so long as its temperature remains *above* 80° F. (which is the dew-point for that amount of water). But as soon as the air is chilled—no matter by what method, whether by elevation or by transfer to cooler regions at the same level or in any other way—a proportion of this vapour will descend as mist or rain. Thus, if its temperature be reduced by twenty degrees (to 60° F.) it will lose about half its water-vapour contents ($5\frac{1}{2}$ grains) in the form of liquid water.

If a wind carrying moisture comes to a range of mountains across its path it is compelled to rise to surmount the barrier. Roughly speaking, an ascent of 3,000 feet causes a drop of 10° F., whereas to attain the same degree of coolness by moving along the level toward the Poles in the latitudes with which we are dealing it would be necessary to travel approximately 700 miles.[1]

[1] The mean annual temperature in the latitudes under consideration decreases approximately one *Fahrenheit* degree for each *geographical* degree (70 miles) traversed on the southward path.

The relation of the chief wet areas of the World to the dominant winds and highlands is clearly shown in Fig. 14; but an example of local conditions may make the relative values of these two important methods (by transfer or by elevation) of temperature-decrease somewhat clearer.

Let us imagine a sea-breeze arising near Cairns in northern Queensland. Here the Bellenden Ker Mountains reach a height of over 5,000 feet within a few miles of the sea. If the sea-breeze succeeded in crossing these mountains its temperature would decrease nearly twenty degrees, and a large proportion of its water would fall as rain. But how far would the wind need to travel south *at sea-level* to suffer a like loss of temperature? In July the isotherm of 70° F. passes through Cairns, while the 50° F. is not reached until we arrive at Cape Howe, fifteen hundred miles south!

Unfortunately Australia has few land-masses over 3,000 feet high, and these are practically all grouped along the eastern coast, in which region (see Fig. 13) the maximum rainfall occurs.

Another factor leading to the further betterment of the Australian coast is the presence of the land and sea-breeze. The land becoming more strongly heated than the sea during the day warms the air overhead. The colder, denser air over the water displaces this light air and flows in as a moist layer at the surface, constituting the sea-breeze. Along the eastern coast the sea-breeze cannot travel far inland without meeting an obstacle in the Eastern Highlands. Indeed the buttresses of the latter are washed by the waters of the ocean along a large portion of the eastern coast, although the actual divide may be a hundred miles or more away. The upward deflection of the air-currents caused by this barrier results in a further increment of rain on the windward (or coastal) slopes of these mountains.

An examination of Fig. 13 (in conjunction with Fig. 4) will show how fully this reasoning is borne out. The central portion of Australia has a normal annual rainfall of less

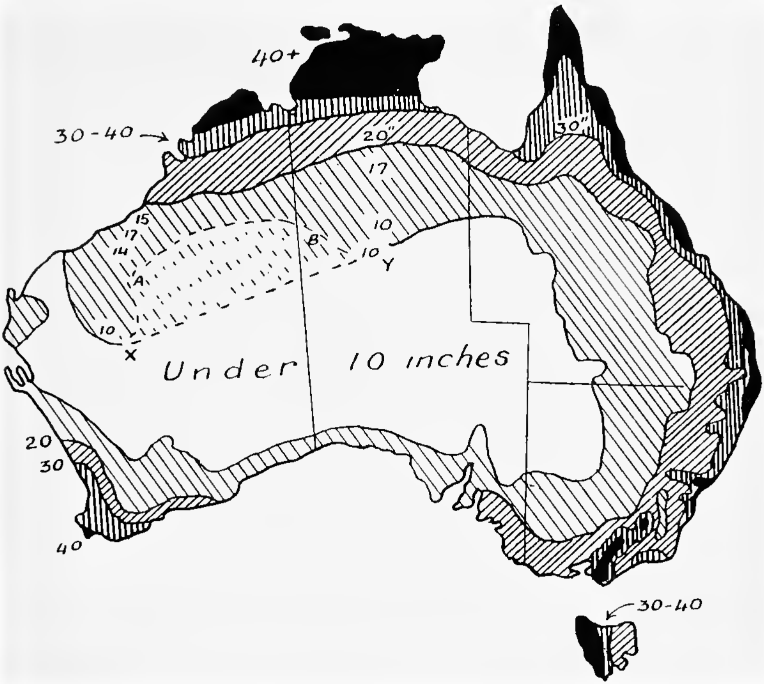


Fig. 13. Rainfall of Australia, from the *Commonwealth Year Book*, 1907. The 10-inch line is shown to run as XABY instead of XY which is admittedly hypothetical.

than 10 inches.[1] This is due partly to the absence of any elevated land-masses—which would, under normal con-

[1] The official map shows the 10″ isohyet in West Australia as a straight (broken) line from X to Y. A careful study of the explorers' narratives dealing with this region leads me to the belief that the isohyet more nearly approaches XABY.

ditions, result in the elevation and cooling of water-bearing air-currents, and thus bring about rain; and partly to the unbroken character of the coastline, which precludes the advent of moisture-laden winds in the far interior to a much greater extent than in a continent like Europe—with great inlets and lowlands facing the prevailing winds. The low rainfall, however, is mainly due to the fact that Central Australia lies in the zone where the trade winds originate.

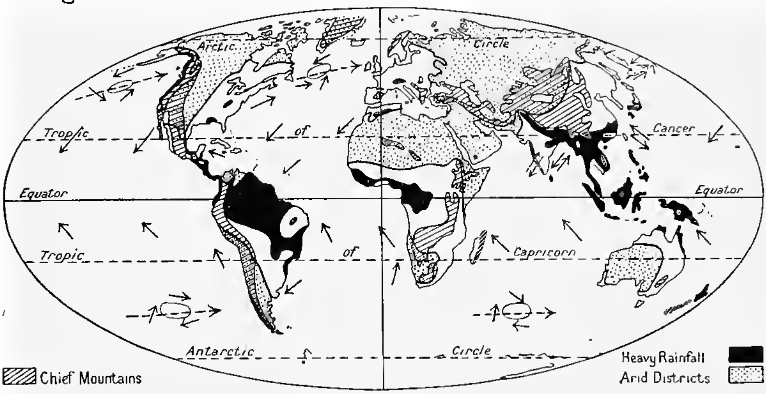


FIG. 14. Winds and Rainfall of Globe.

Most of the great deserts of the Earth occupy roughly similar positions with respect to the tropics of Cancer and Capricorn. Over these regions the winds for a large part of the year blow *from the land* to the sea and *towards warmer areas*, so that they tend to absorb moisture rather than to deposit any.

A glance at Fig. 14 will demonstrate this. The south-east trades in the Southern Hemisphere are in this sense connected with the Australian Desert, the Kalahari Desert, and the Atacama Desert. The north-east trades are associated with the Colorado Desert and the Sahara. The Central Asiatic Desert is of a somewhat different nature, the air-currents being dominated by the monsoons rather than by the trade winds.

Surrounding the central dry area of Australia the isohyets (lines of equal rainfall) describe almost concentric curves, any modifications being almost entirely due to variations in elevation. Thus the Darling Ranges to a great degree account for the comparatively good rainfall of the south-west corner of Australia. The Flinders Range (South Australia) and Snowy Mountains in the south-east have heavier rainfalls than the surrounding tracts owing to their cooling effect on the air-currents. Along the eastern elevated margin of Australia every ridge between large river valleys accounts for a somewhat greater rainfall. Examples of the latter type are the Peak Range and Darling Downs in Queensland. Where the eastern ranges of Northern Queensland (Bellenden Ker, &c.) obstruct the tropical monsoons—of which the south-east is the dominant—there occurs the

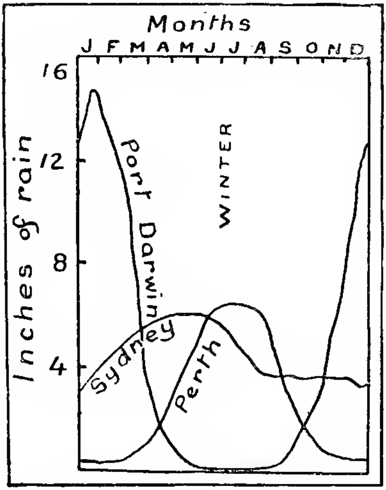


Fig. 15. Seasonal Rainfall at Port Darwin, Perth, and Sydney.

heaviest rainfall in Australia. In Western Tasmania there is a superfluity of rain for similar reasons, where, however, the 'Stormy Westerlies' play the part of water-bearers.

The rainy seasons in such a large area as Australia are by no means the same over the whole continent, and this section may well be concluded by a brief account of the cause and effect of the seasonal distribution.

As we shall see in the next section, the southern portion of Australia is one of those regions characterized by winter rains, while the chief rains of the rest of the continent occur in summer and are due to quite different causes.

The diagram (Fig. 15) shows the contrast between the seasonal rainfall of Port Darwin in the extreme north, and Perth in the south-west. The northern town gets its rain in the hot summer months (December—February), when the Sun is furthest to the south and the heated centre of Australia causes a surface inflow (the monsoon) of moisture-laden winds from the ocean. The greater portion of the rainfall is confined to the immediate neighbourhood of the northern coastline, for as there are no mountains of importance projecting above the 1,500-foot plateau south of this region there is no tendency for the monsoon to become chilled and part with its moisture as it moves south.

In the south of Australia the rainfall occurs chiefly six months later (June—August) when the whole wind-circulation of the globe swings north in accord with the Sun. For this reason the constant westerlies, which—as their name 'Roaring Forties' implies—usually blow considerably to the south of Australia, during the colder months blow across the south-west corner of Australia and across Victoria. There are fairly elevated ranges here—such as the Darling, Flinders, and Otway Ranges—hence the winter rains of Perth and Adelaide; which are well suited for the growth of wheat (see pages 155–8).

We have now to consider the two remaining areas, namely the Arid Central Area, and the eastern intermediate region containing Brisbane (and southern Queensland generally) together with most of New South Wales.

The rainfall in Central Australia occurs at rare and irregular intervals, being generally due to local atmospheric disturbances such as thunderstorms. I have started out, under apparently normal weather conditions, in the arid regions east of Lake Torrens—where not a drop of rain had fallen for nearly a year—and within half an hour I have been driven back by a tremendous rainstorm which flooded all the creeks and covered the whole district with a sheet of water. The meteorology of the desert rainfall has not been investigated, but probably here—as elsewhere—these sudden and violent rainstorms are due to unusual instability in the atmosphere. If a pronounced difference arises between the temperature of the lower *warmer* air and upper cooler air, the former tends to rise,[1] and a large body containing much water-vapour may rise to a point where the temperature is a good deal below the dew-point. Hence drops of rain form and these gradually coalesce. At the same time the electrical charges which always exist to some degree on their surfaces are added together, and finally become too concentrated for the reduced surface areas of the *coalesced* drops. Hence the electric discharge which usually accompanies such storms.

There is no doubt that certain inter-relations of the cyclone and anticyclone whirls favour the fall of rain in this central region. At rare intervals it may happen that a northern cyclone extends so far southward between two successive anticyclones that it reaches almost to the

[1] Russell (in his *Meteorology*, p. 125) states that this interchange of air will take place if the decrease of temperature with height is greater than 0·58 of a degree in 100 feet.

southern shore of the continent. This is called a *monsoonal tongue*, and it draws in moist air to the dry regions, where the ascent of the air in the low-pressure area may give rise to rain much as in the case of the thunderstorm mentioned in the preceding paragraph. This type of rainfall is, however, more fully described in the next section.

In the eastern intermediate area (containing Brisbane and Sydney) there is a tendency toward more uniform seasonal distribution. This is to be expected, for the rainfall does not depend on the monsoonal winds nor on the *northward* extension of the area of stormy westerlies, but on the regular passage of the anticyclones across Australia.

In Fig. 12 we have two weather charts which are of a common type. In *A* are two anticyclones moving in the belt of high pressure, while a cyclone (*low*) has its centre over Kangaroo Island in the South Australian Gulf. The first *high* gives rise to winds blowing spirally outwards and having a tendency to blow to the south over New South Wales towards the area of low pressure shown in the figure. The warm, moist winds blowing from the Queensland coast to the cooler regions of Australia will be rain-bearing winds. So that rain would be experienced in the low-lying regions of the Riverina and Northern Victoria. The centre of the cyclone (or *low*) will also probably be wet since here the moist air of the South Australian gulfs is rising to cooler layers of the atmosphere, and cold, wet conditions ensue for the same reason as before.

In a few days the whole system has moved a thousand miles to the east (see Fig. 12 *B*). Most of Western Australia is covered by the anticyclone, and therefore experiences dry, bright weather, since the winds flowing down the centre of an anticyclone become warmer and absorb moisture. The winds blowing outwards from the land to the sea also tend to absorb moisture, so that no rain may be looked for in these areas. The *low* is just leaving Australia, and the winds at its rear flowing from the cool south to a warmer land will not give rise to rain under the conditions assumed.

SECTION III. THE NATURAL REGIONS OF AUSTRALIA

CHAPTER V

AUSTRALIAN VEGETATION

BEFORE passing on to consider the separate geographical units of which Australia is composed, with their individual industries and environments, it seems advisable to make a brief survey of the most easily utilized gift of nature to man—the vegetation of the continent. The broad features are shown in Fig. 16, and are obviously almost wholly dependent on rainfall.

The tropical forests are naturally found in the North, chiefly in Arnhem Land, around the gulf of Carpentaria, and especially along the north-east coast of Queensland. Near Geraldton is the heaviest rainfall in Australia, and here it will be found—as the writer discovered—easier to penetrate the 'scrub' on all-fours—owing to the mass of canes, lianas, and creepers—than to progress in an ordinary position. The forests consist largely of soft-woods—the eucalypts being comparatively rare—and an 'outlier' of somewhat similar timber, known as the 'Soft-wood Brush' occurs as far south as the north-east of New South Wales. The extent of these tropical forests is not well known, but they are somewhat irregularly distributed throughout the coastal tropical districts where the rainfall exceeds thirty inches.[1]

[1] Data as to the *less thickly timbered* districts in the tropics is not available. I have therefore classed it as arable. The reader (acquainted with German) is referred to Diel's work on the West Australian Flora, for an interesting discussion of the flora of the continent.

The great Eucalypt Forests occur in the well-watered coastal regions of the south-west corner and east of the continent. Although in certain regions they form dense masses of timber, as in Gippsland, yet in general they are of an open park-like character with little underwood.

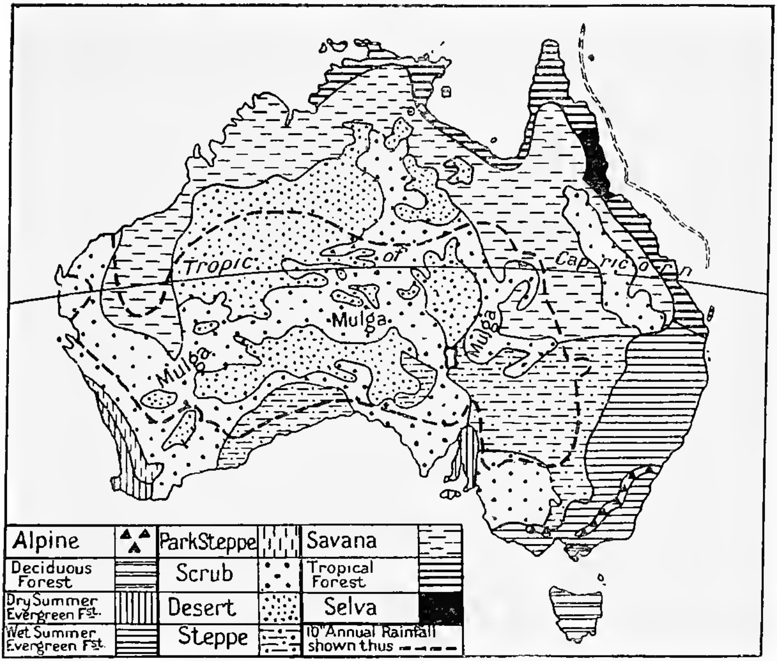


FIG. 16. Vegetation of Australia.

For this reason grass grows fairly well in these regions and they are eminently suited for pastoral purposes.

They differ greatly from the Coniferous Forests of Europe—so thick that the sunlight does not reach the needle-covered carpet beneath—or the shady groves of oaks and beeches with their swelling masses of foliage. It is, however, incorrect to say that the eucalypts give no shade, for many have quite broad leaves. When they are young all have a comparatively close foliage, but as they grow old they usually become gaunt, sparsely-leaved giants. This gives Australia a characteristic, and to some people a repellent, style of scenery.

Gradually as the more arid regions of the continent are approached the large trees become more and more isolated. Along the watercourses long files of gums form an advanced guard as it were—where the river has the same effect as a more copious rainfall. Thus the forests merge imperceptibly into the park-lands and these into the prairies.

The whole area marked out in the map by dots or lines is suited—so far as the rainfall is concerned—for agriculture. In fact the timber areas are superior to the prairies in most cases, and the best land has passed through the stages of 'ring-barking' and 'burning-off'—a wasteful but hitherto apparently necessary preliminary towards agriculture. Experience seems to show (see wheat map, p. 152) that in the south crops can be grown with an annual rainfall of less than fifteen inches, but in the north the limit of agriculture moves much farther away from the arid centre of the continent. There is, however, no agriculture in the tropics except in a narrow fringe along the coast.

Much of the area characterized as prairies (on the map, Fig. 16) would more properly be termed steppes, all, in fact, within the ten-inch isohyet. This large eastern portion (white on map) of the area with less than ten inch rainfall has been divided into a Lower and a Higher Steppe. The former comprises the Lake Eyre Basin and largely consists of 'gibber plains' (barren stony wastes, of which Sturt's Stony Desert is an example) or less barren loamy tracts supporting some saltbush. The Higher

Steppe includes the Highlands of Central Australia, and portions of it are well grassed (see pages 116–17).

The greater part of the white area on the map is suited for pasture, provided that sufficient grazing ground be allotted to each head of stock. In drought seasons, however, the food-supply within the ten-inch isohyet is very small and almost necessitates a transfer of all the stock to less arid regions.

Between the grass-land zone and the desert flourish the indigenous salt-bush and blue-bush.[1] These are both low fleshy-leaved shrubs, with a characteristic grey colour, on which sheep feed eagerly. This zone gives place to the monotonous wastes shown in black on the sketch-map, where the wind has swept the sand into long parallel ridges, while the only vegetation consists of thickets of wiry 'mulga' (a low acacia) and the prickly 'porcupine grass'. Here is no possibility of pastoral occupation. Indeed it is only in winter that enough water and feed exist to allow the explorer to cross (pp. 111–12. So that it seems doubtful if a permanent stock route can be established between Northern Territory and Western Australia such as exists between Hergott (South Australia) and Queensland (see p. 146).

There is one small region in Australia where another factor—elevation—greatly influences the vegetation. In the Australian Alps in the south-east, the land rises above the tree-line, and here an alpine flora appears when the snows melt. But the sturdy 'mountain gums' rise to the 5,000-foot level, so that the alpine area is quite small and of little economic importance.

[1] A good account of these valuable native fodder plants is given by Mr. Maiden in the *New South Wales Year Book*, 1905-6, p. 756.

CHAPTER VI

THE CORRELATION OF GEOGRAPHICAL REGIONS

SINCE the factors affecting the climates of the various regions of the World are to a certain extent symmetrical about the equator, and since it has been shown (page 38) that there is a definite arrangement to be observed in the position and shape of the great land-masses, it follows that there should be a certain similarity of climate, not only in regions along the same latitude but also in regions approximately the same distance on the other side of the equator.

The striking relation between the great deserts of the World and the trade winds has already been indicated (see Fig. 14). A similar arrangement of the wetter regions of the World is also observable. In each hemisphere we have the region of westerly winds; blowing constantly in latitude 40° S. and not so regularly in latitude 45° N. Arising from this air-current we have three well-defined wet regions in the southern hemisphere, namely southern Chili, Tasmania, and New Zealand (South Island). In the northern hemisphere similar conditions obtain in British Columbia and Ireland. On the eastern shores of the great continents we have much drier regions with a fair rainfall having great similarity in climate. Such are Uruguay, Natal, New South Wales; and in the northern hemisphere the eastern states of U. S. A. and China.

Such similarity in climate and position must react on the life and industries of the inhabitants, and a study of this question may well form the basis of a general scheme of geographical regions which should be very helpful in connexion with that branch of economics dealing with supply and demand. For it will be seen that the products of any one of these analogous regions are those of the others, or if not already there will probably thrive if introduced. For instance, China grows *silk* and *tea*, U. S. A. grows *cotton*, New South Wales at present has not passed the experimental stage in any of these crops but (apart from

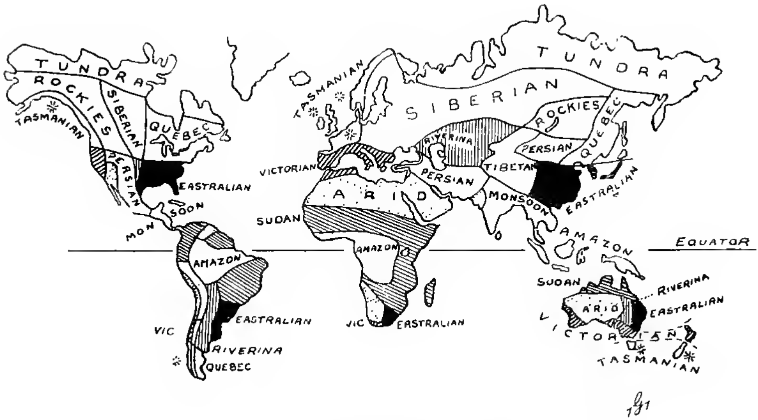


FIG. 17. Correlation with Australian Climates based on A. J. Herbertson's Regions. Regions allied to Australia are tinted.

labour conditions) there is no geographical reason why they should not do well in certain portions of the mother state of Australia.

This line of research has been ably developed by Dr. Herbertson,[1] and Fig. 17 is based on his map, being altered, however, to suit Australian conditions. On this plan Australia may be divided into six climatological regions.

[1] 'Major Natural Regions,' *Geog. Journal*, vol. xxv, p. 300, 1905.

1. Savana.
2. Desert.
3. Eastralian.
4. Riverina.
5. Victorian.
6. Tasmanian.

1. **Savana.** These regions consist of moderately elevated land situated between the tropics and the equator; they have a hot, moist climate and are not well situated for white occupation. In the Australian province cattle and sugar are the only large industries (excluding mining). Allied provinces are Sudan and Southern Brazil. In these countries large crops of rice, sugar, tobacco, rubber, and cotton, together with less important products are grown, and would probably flourish equally well in the Australian province.

2. **Desert or Arid.** In the Australian province a certain portion is used as pastoral land, what may be termed 'oases' occurring, specially near the MacDonnell Ranges. As in the other regions, Sahara, Kalahari, Atacama, Arabia, Arizona, it is only sparsely inhabited, civilization concerning itself with the preservation of travelling routes by means of artificial water-supply. However, where rich mineral deposits occur, as at Coolgardie, Atacama, &c, large settlements may flourish.

3. **Eastralian.** This comprises in Australia the Eastern and Central Divisions of New South Wales and Southern Queensland. It is characterized by a warm, temperate climate (45°–70°) having a moderate rainfall, mostly falling in summer, varying from 20″ to 70″ according to the distance from the coast. It is pre-eminently a farming country, being devoted largely to dairying and small crops generally. Cattle pay well in the more elevated regions. Allied regions are China and Eastern U. S. A., where, however, the winters are much colder. Hence, in addition to the above items, silk, cotton, and tea may be cited as possible products of agriculture.

4. **Riverina**. This name is given to the western region of New South Wales watered by the lower portions of the great tributaries of the Murray River, i.e. Darling, Lachlan, Murrumbidgee, and Murray itself. It is thus a region of interior lowlands with a warm, dry climate, excelling in the production of wool and wheat. Allied regions are found in the prairies of N. America, the pampas of S. America, and the plains of Southern Siberia. These are also great wheat-growing regions, and are ahead of Australia in that respect, but as a wool-raiser the Riverina country is perhaps the best in the world.

5. **Victorian.** These regions have a warm, temperate climate, somewhat colder, however, than the preceding. The greatest rainfall is in the winter. At this period the Sun moves north and is followed by the general wind system. Hence southern Australia is brought more under the influence of the moisture-laden westerlies, whose track is *south* of the continent in summer. Analogous regions are the Mediterranean countries, Cape Town, &c. As in Australia, these provinces excel in the growth of vines, olives, cattle, wheat. It will be noted that though the products are the same in both northern and southern regions yet the times of harvests differ very considerably in the two cases, a fact of increasing importance in connexion with the supply to the great northern populations.

6. **Tasmanian.** Cool, temperate climate, considerable rainfall, and snow by no means rare. Chief products are fruit, sheep, and timber. Similar conditions resulting in similar products occur in New Zealand, Western Europe, British Columbia, and South Chile. It is noteworthy that their waters are usually good fishing-grounds while the climate is one of the most pleasant in the world.

Although these climatological regions are of the utmost value for comparison with similar regions in other continents; yet as regards its internal physiography Australia can be more satisfactorily divided into five topographical regions. Of these three (A, D, E) are well defined, and two (B, C) are somewhat arbitrary.

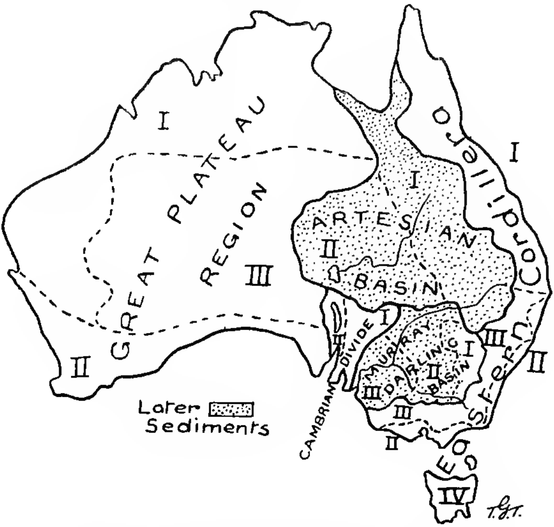


FIG. 18. Topographical Regions of Australia.

A. Eastern Highland or Cordillera Region: I, Queensland Highlands; II, South-east Littoral; III, South-east Highlands; IV, Tasmania.

B. Murray-Darling Basin: I, Gold-copper Slope; II, Western Plains; III, Tertiary Sea.

C. South Australian Highlands and Rifts: I, South Australian or Cambrian Highlands; II, Torrens Rift.

D. Artesian Basin: I, Eastern Division; II, Lake Eyre Basin.

E. Great Plateau Region: I, Tropical Division; II, Temperate Division; III, Desert Region.

(A) The Eastern Highlands.

(B) Murray-Darling Lowlands.

(C) South Australian Highlands and Rifts, or the Cambrian Divide.

(D) The Great Artesian Basin.

(E) The Great Tableland or Plateau Region.

The dominating feature in the continent is the huge mass of very ancient schists, granites, and palaeozoic sediments which form region E, and constitute the greater portion of the states of West and South Australia. In fact they build up one of the oldest land masses on the globe. During later periods the Eastern Cordillera Region (A) was elevated above sea-level, not all at once but probably at the close of the palaeozoic age most of it was dry land. The sediments deposited between these two land areas have been raised above sea-level in still later geological times, and constitute the Artesian and Murray-Darling Regions (D and B). The geological history of these regions is discussed more fully later.

CHAPTER VII

THE EASTERN HIGHLANDS OR CORDILLERA AREA

Eastern Highlands. This is a belt of country which runs parallel to the eastern coast from Cape York round to the mouth of the Murray. It has an average width of 150 miles and contains the chief mountains in the continent. The seaward slope is in general steeper than that on the west, and the Blue Mountain Scarp (N. S. W.), the bold front of which opposed the western march of settlement, is directly due to a great fold which occurred in late Tertiary times and which has definitely altered the direction of several of the rivers (i. e. Nepean and Shoalhaven). Professor Gregory has pointed out the lack of uniformity in the structure of this Cordillera. Granite masses of a different age from most of the elevated *sediments* build up the Grampians in the south-west, slate and granite form the dome of Kosciusko (7,320). Granite again appears in the New England Highlands. The sedimentary formations from the lower silurian to the trias, with varied axes of uplift, have a part in the structure of the Highlands, so that it is not a homogeneous mountain range like the tertiary mountain chains such as the Andes.

There are four natural divisions.

In the north are the Queensland Highlands.

In the south-east the Cordillera is set somewhat further back from the coast than in Queensland, and it is convenient to divide the region into two parts: — the

South-East Coastal region (A II) between the eastern edge of the elevated area and the ocean, and the South-East Highland (A III) which may be conveniently assumed to be bounded by the 2,000 foot contour line (see map, p. 26).

The fourth region is Tasmania.

The Queensland Highlands.

The first natural division consists of the Queensland Highlands, culminating in the Bellenden Ker Mountains (5,440 ft.). This region broadens towards the south where it has a width of about 300 miles. For some 1,200 miles it is flanked by the reefs of the Great Barrier whose steep outer margin is some 30 to 75 miles from the coast line. Within this wall, where each small reef represents a battlement, is an inland sea averaging some 20 fathoms deep, along which sail the steamers trading to and from China, India, and Japan. The trade in pearl-shell, tortoise-shell, and bêche-de-mer is described in another section (Chapter XIX).

The coast is in the main rocky, and is fringed with islands which are relics of the subsidence of coastal ranges. Hence there are many good harbours, though level agricultural land is correspondingly rare. The river bottoms are devoted to sugar-cane (see pp. 202–4), and in the north where a heavy rainfall obtains (Geraldton between Cairns and Townsville has 145 inches per year) all tropical productions are grown. The chief towns are situated where the rivers enter the sea or at the numerous goldfields in the Cordillera. Cooktown supplies the Laura Goldfield, and incidentally New Guinea. Cairns is the port for the Chillagoe tin and gold fields. Sheep and cattle from northern Queensland and gold from Charters Towers are brought by rail to Townsville. The Burdekin River enters the sea between Bowen and Townsville but is of much less importance than the other large river draining the Queensland Cordillera, the Fitzroy, which debouches into Keppel Bay 35 miles below Rockhampton. Here a railway stretches some 400 miles inland and its course almost coincides with the tropic of Capricorn.

The valley of the Fitzroy will become one of the most populous parts of Australia, for sheep and cattle are numerous and supply the large meat works near the coast. Mt. Morgan, until lately one of the richest gold mines in the world, is 26 miles south of Rockhampton. The Dawson River Coalfield, however, is probably the chief asset in this portion of the Queensland Highlands, though as yet it is an almost untouched source of wealth. South of Rockhampton the Highlands increase gradually in height and culminate in the New England massif in New South Wales.

The same general features as those described for the northern part of Queensland characterize its southern portion. Sugar ports, such as Bundaberg and Maryborough, also serve as outlets to mining districts such as Gympie and Kilkivan. A very flourishing area of basalt country known as the Darling Downs is chiefly devoted to agriculture. The railway to Brisbane from its chief town, Toowoomba, also taps the Ipswich coalfields—the chief coal area in Queensland. The south-east coast of Queensland is free from coral reefs but there are large sandy islands which somewhat impede navigation, such as Great Sandy, Moreton, and Stradbroke Islands. The capital, Brisbane, is situated in the south-east corner of the State, and is partly for this reason much less a State metropolis than are the central cities of Sydney and Melbourne. With a population of only half a million, Queensland has as many second-class towns with over 10,000 inhabitants as has New South Wales, and more than Victoria, though the latter States

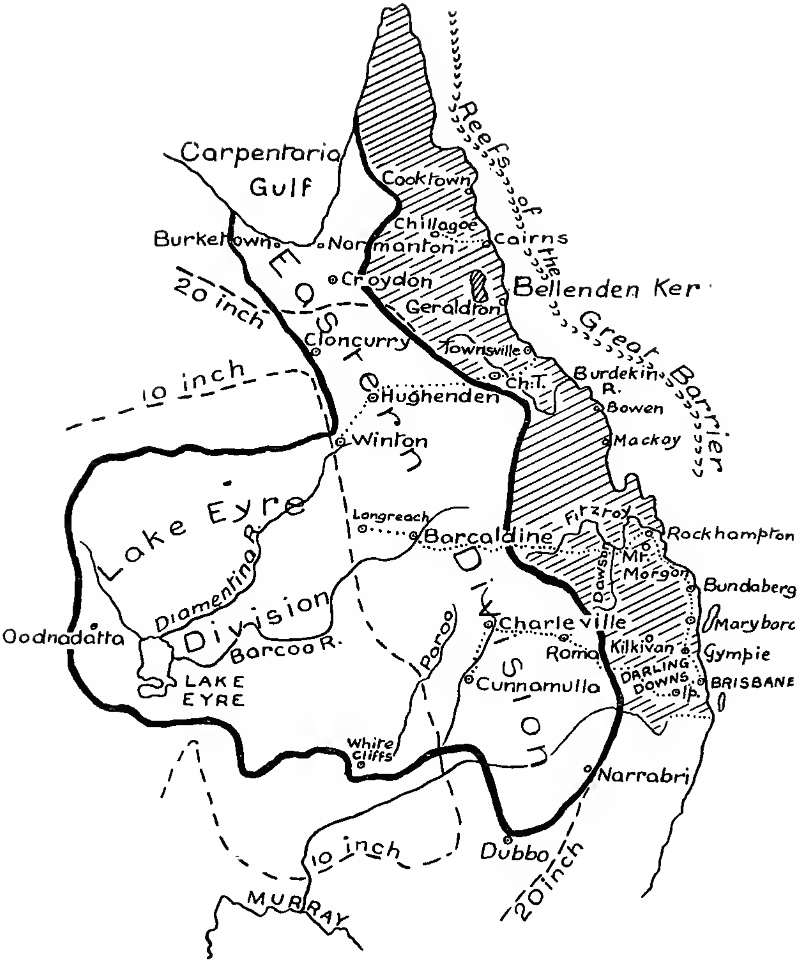


FIG. 19. The Queensland Highlands (A I) and the Artesian Basin.

have one and a half million inhabitants each. Indeed the whole population of Queensland would barely replace numerically that of either Sydney or Melbourne.

The South-East Coastal Region.

The South-East Coastal Region may be said to extend from the Macpherson Range on the Queensland border to the Mount Gambier district in the south-east corner of South Australia. It is a strip of land which varies in width as the lower river valleys are wider or more circumscribed. Thus, in New South Wales the Richmond and Clarence drain a tract of country 50 miles wide after they leave the highlands. Spurs from the New England Range isolate the smaller valleys of the Macleay and Manning, and then the littoral region spreads out again into the broader valley of the Hunter River. The Tweed, Richmond, Clarence, Macleay, and Manning are grouped together as the **North Coast Rivers**. The rainfall is abundant and the vegetation is therefore, in general, very luxuriant. The first settlers were attracted by the valuable cedar, but sugar-cane and dairying have since become of much more importance. Murwillumbah on the Tweed, Lismore on the Richmond, and Grafton on the Clarence are the main centres of population. Navigation is impeded by bars in most of the rivers, but ocean-going steamers drawing 11 feet of water can reach Grafton, which is 45 miles from the ocean. The lower Hunter valley extends nearly 80 miles from the coast, and forms the widest part of the littoral region. Here the northern edge of the great coal basin of New South Wales crops out. It would appear as if the softer coal measures have enabled the Hunter to cut back more rapidly than the Hawkesbury River has been able to do, for the latter flows through *hard* trias sandstones somewhat farther south (see Fig. 38).

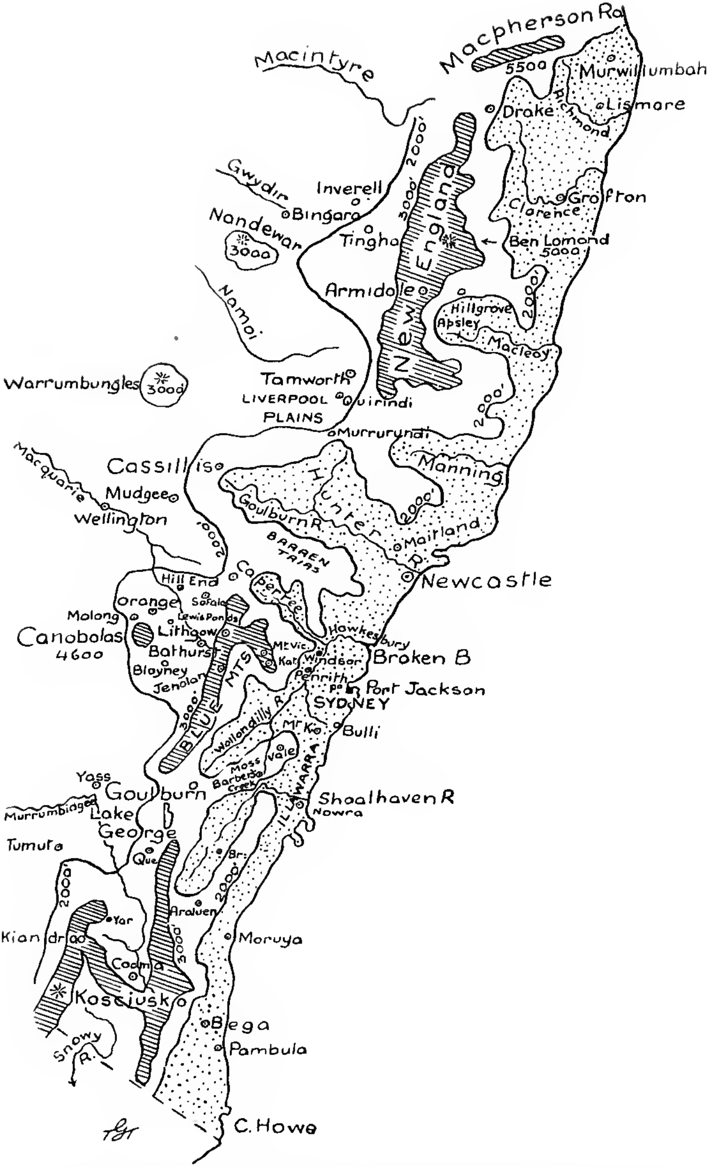


Fig. 20. The Orography of the New South Wales Cordillera, indicating the Three Massifs (hatched) and the Littoral Portion (dotted). (From maps in the writer's paper on Contour and Climate, 1906; based on work by H. E. C. Robinson.)

The Hunter River flats around Maitland are renowned for their fertility, but are liable to disastrous floods, though the upper valley of the Goulburn—the chief tributary—is the driest portion of the littoral (see page 122). Two fine harbours, Broken Bay and Port Jackson—both drowned river valleys invaded by the sea—lead into the coastal belt in the section farther south. Broken Bay receives the Hawkesbury River, 330 miles long, one of whose tributaries, Cataract River, rises only 2 miles from the coast (near Bulli 40 miles *south* of Sydney), and flows west (Cataract River), north-west (Nepean River), north, north-east (Hawkesbury River) and south-east, thus forming a semicircle round Sydney. Port Jackson receives no river, the so-called Parramatta River being only an arm of the sea some 10 miles long. The pre-eminence of the harbour at Sydney is no doubt largely due to this fact, no dredging being necessary to keep open the deep water frontages. The trias sandstones of the county of Cumberland are poor in plant foods (see p. 18), but an upper layer of clay-shales around Parramatta supports many orchards. The Hawkesbury River flats near Windsor and Penrith below the Blue Mountain Scarp are the chief agricultural areas. The coal-mining and dairying industries are discussed in separate sections.

South of Sydney the littoral belt is much narrower for some distance. The first well-marked district is the important **Illawarra** dairy country which surrounds the lagoon 'Lake' Illawarra and the mouth of the Shoalhaven River. In the ranges behind the dairy farms excellent coal crops out. As the rainfall is good this is one of the most flourishing districts in Australia. Bulli and Mount Kembla are the chief coal centres; while Nowra, near the mouth of the Shoalhaven, is the railway terminus and a collecting-ground for agricultural and pastoral products.

The **South Coast region** is confined to the river mouths. The mountain spurs reach the coast and contain many small mining fields (e.g. Moruya and Pambula) chiefly of gold and copper. Moruya (150 miles south of Sydney), on the river of the same name, and Bega (200 miles south of Sydney) are the chief towns, and, in common with the whole district, are devoted to dairy farming.

Fig. 21. Victoria.

When Cape Howe is passed there is a somewhat different distribution of mountain and plain. The littoral region becomes much wider than in the south of New South Wales and merges gradually into the region called by Professor Gregory the Great Valley of Victoria. The latter is separated from the sea by the low Otway Ranges and the Gippsland Hills to the west and east of Port Phillip respectively. The low coast lands continue west across the mouth of the Murray to the Mount Lofty Ranges which constitute their western boundary. But it will be more convenient to consider the South Australian portion of the coastal belt with the Murray Basin, to which it is structurally akin.

If now we examine the Victorian portion in some detail, we see that **Gippsland** extends roughly from the Snowy River to Mount Macedon, near Melbourne. It is one of the most prosperous portions of Australia and one of the most interesting and beautiful. The greater width of the littoral belt here is probably due to an uplift of the coast, which has added a wide stretch of level country to Victoria, and led to the formation of the Gippsland lakes. There is little doubt—as Professor Gregory points out—that the Rivers Tambo, Mitchell, Thompson, and Latrobe had independent entrances to the sea when the rocks which now form the coastal plain were laid down, 'but now they have all been grafted on to one another till they form one system. The Gippsland lakes occupy the depressions along the courses of the members of this engrafted system.'[1]

In the older rocks enclosing this coastal plain are gold-mining fields, of which Walhalla is the most noteworthy. Sale is the capital of Gippsland and is the centre of a large dairying and pastoral district. Somewhat nearer Melbourne is Morwell, where coal of a somewhat inferior quality is abundant. In the county of Buln-Buln, enclosed between the two railways joining Melbourne to Sale and Port Albert respectively, is a richly timbered country where the largest hardwood trees in the world flourish.[2] 'These mammoths of the forest,' says Mr. Easterby of the *Eucalyptus amygdalina*, 'shoot up to a height of from two hundred to three hundred feet without a branch marring their splendid pillars. One burned to the ground was found to be, within the hollow recess of its stump, twenty-

[1] Gregory, *Geography of Victoria*, 1903.

[2] Semon states these trees reach 480 feet in the Dandenong Mountains. *If* this be so they are much higher than the Sequoias of California (vide *In the Australian Bush*, p. 30, Macmillan, 1899).

five feet across.' The Gippsland lakes (Wellington, Victoria, and King) are favourite summer resorts and furnish large supplies of fish to the Melbourne market.

Port Phillip is probably a drowned area of the Great Victorian Valley, and is about 40 miles wide and the same distance from the entrance to the head at Melbourne. The latter city is admirably situated to collect the produce of Victoria, for it is more central than any other Australian capital and, owing to the less rugged nature of the highlands behind, the inland areas of Victoria were connected by rail to the capital much sooner than in New South Wales. Port Phillip Bay extends over 800 square miles and forms a good outer harbour for Melbourne. Lying within it Hobson's Bay is protected on the south-west by the point on which Williamstown has grown up, and though most large vessels berth here (adjacent to Port Melbourne), yet steamers drawing 22 feet can enter Melbourne up the Yarra.

To the west of Port Phillip the valley extends to the South Australian border; the western district was christened **Australia Felix** by its discoverer, who reached it across the 90 mile desert of South Australia. The nearer portion of the south-west plain of Victoria owes its great fertility to the immense areas of basalt, which flowed from many extinct volcanic cones such as those around the salt lakes of Corangamite. The country here is chiefly pastoral, though further west agriculture is all important. At Warnnambool and Belfast is a population largely of Irish descent, and here pigs and potatoes are important assets in the district's wealth. Tower Hill, a well-known volcanic cone in the vicinity was possibly the last active volcano in Australia. Portland was founded by some whalers from Tasmania—the first settlers in Victoria. They soon, however, turned their attention to sheep and at a later period bred the finest sheep in Victoria near the neighbouring town of Hamilton.

The western end of the South-East Littoral lies in South Australia. Around the crater lakes of Mount Gambier are large areas devoted to the growth of English fruits, potatoes, grain, and grasses, while many sheep are reared. But beyond this lies the raised sea floor of the large tertiary gulf in towhich the Darling, Murrumbidgee, and Murray originally entered by separate mouths. The littoral portion of this old sea floor is best considered with the Murray-Darling region, for it can hardly be considered a portion of the Eastern Highland region whose last important heights are the Victorian Grampians.

Summarizing the districts of the South-East Coastal region, they comprise in New South Wales (1) The North Coast, (2) the Hunter Valley, (3) the Sydney District, (4) the Illawarra District, (5) the South Coast District; and in Victoria (6) the Gippsland District, (7) Port Phillip, (9) the South-Western Plain of Victoria.

The South-East Highlands.

The Highlands forming the hinterland of the South-East Coastal Region can be divided into several well-marked elements. In New South Wales there are (1) The New England Massif, (2) the Blue Mountain Massif, and (3) the Kosciusko Massif, separated by cols which are used for routes to the interior, and (4) the Victorian Highlands. (See Figs. 20, 21.)

The New England Massif.

This is composed chiefly of sediments of carboniferous age into which large masses of granite have been intruded.

It extends from the Queensland border some 250 miles to the south (see Fig. 20) and is approximately 100 miles wide, with a broad off-shoot—the trachyte bosses of the Nandewars—extending towards the west. It is thus the most considerable mass in the Eastern Highlands, a large proportion being over 3,000 feet (Ben Lomond, 5,000).

It forms the divide between the Macintyre, Gwydir, and Namoi Rivers on the west and the Clarence, Macleay, and Manning on the east. The head waters of the coast rivers arise in the most rugged country in the State where the timbers differ considerably from those in other parts, consisting chiefly of soft woods. (See the section on timber.) Apart from small mining towns such as Drake and Hillgrove, there is little settlement; though the numerous waterfalls—such as Apsley Falls (200 feet) on a tributary of the Macleay—point to a development of water power in the future.

On the western slopes of the New England Massif the country is much less rugged and the mining industry is accompanied by agriculture and sheep rearing. The main northern railway follows the centre of the tableland where Armidale is a centre of the squatting industry. Inverell and Tingha, to the north-west of Armidale, are in the chief tin-field in New South Wales, while Bingara has produced many diamonds. Wheat is largely grown on the lower portions, as at Tamworth and Quirindi, which are on the borders of the Liverpool Plains.

For about 100 miles south of the New England Massif the Highland is much less elevated and at three points is little above 2,000 feet. At Murrurundi—the northernmost of these gaps—the railway crosses from the Hunter valley to the Liverpool Plains. The central gap, the Cassilis Col or gap, is largely due to the erosive action of the Goulburn river on the relatively soft coal measures constituting its bed. It forms a natural route from the Hunter valley to the gold-fields of Mudgee and Wellington. The southern gap is cut in hard triassic sandstones by the Capertee river which has exposed rich seams of kerosene shale in the cliffs, but these cliffs here offer as great difficulties to travel, as elsewhere in the Blue Mountains, and the route will probably never be of much use.

The Blue Mountain Massif.

The central massif culminates in the Blue Mountains (Fig. 20), which long resisted all efforts of the settlers to

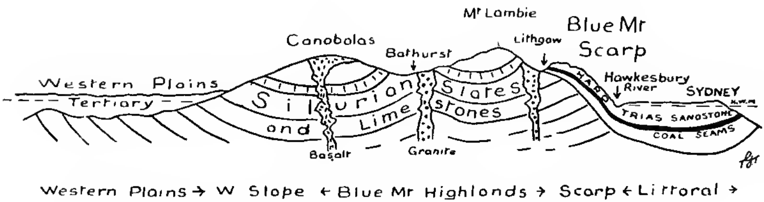


Fig. 22. Section across the Blue Mountain Massif, showing the Structure of the Scarps on the East.

open a route to the west. This is due to their peculiar structure which has given rise to the valleys (e.g. Capertee valley in Fig. 20) which astonished Darwin. He writes, 'Great arm-like bays, expanding at their upper ends, often branch from the main valleys and penetrate the sandstone platform. . . . To descend into some of these valleys it is necessary to go round 20 miles. But the most remarkable feature in their structure is that although several miles wide at their heads they generally contract towards their mouths to such a degree as to become impassable.' Professor David and others have proved that this 3,500 foot barrier—which rises 1,200 feet in the first 4 miles—is due to a single grand fold in the triassic strata (see Fig. 22). It will be understood that when the hard surface layer of this 'giant step' has been cut through by a river (e. g. the Capertee), it is working in softer shales everywhere except where it actually cuts through the scarp; and so it eats away the sides of the upper portion of the valley more rapidly and removes the débris through the narrow opening which is all it has been able to erode in the hard stratum covering the scarp.

The sandstone platform of which Darwin speaks is—except along the railway—almost as barren and desolate as when he saw it about 1835. This is due to the lack of plant food in the trias sandstone, which builds excellent houses but supports a somewhat stunted and worthless vegetation. In the tract of country from Broken Bay to the head of the Goulburn—some 150 miles long and 30 broad—there is scarcely a settlement, and a similar area along the Wollondilly is equally rugged and unprofitable. At the western edge of this barren sandstone the underlying coal measures are exposed; and at Lithgow, where one of the few manufacturing centres of Australia is situated, the blast furnace for iron, the copper refining plant, and the potteries are among the largest in Australia.

The 2,000 foot contour line in this latitude encloses a compact, circular plateau about 80 miles in diameter (see Fig. 20). It is bounded on the east by the Blue Mountain Scarp (above which are the tourist resorts of Mount Victoria and Katoomba), on the south by the Goulburn gap; on the west its limits are less well defined, but the isolated basalt knobs of the Canobolas crown the slope, while on the north it is joined by a narrow neck near Capertee to the desolate trias plateau mentioned previously. This area is shown in section in Fig. 22.

The greater part is drained by the Macquarie and its tributaries. This river rises near the Jenolan caves—one of the grandest examples of limestone erosion in the world —which are visited by thousands of tourists every year. It flows through the Bathurst Plains, to which the early settlers drove their flocks when the coastal belt became too small for them. It drains the earliest gold-field of Australia, Lewis Ponds being the scene of Hargreaves' discovery of payable gold in 1851, while Hill End and Sofala possess quartz reefs rich in the same precious metal. On the western edge of this area arise the old volcanic masses of the Canobolas and around them are the towns of Molong, Orange, and Blayney, which are all wheat-growing, mining, and pastoral townships.

On the western slopes of the Cordillera lies the great wheat belt, and gradually as the base of the Highlands is buried in the alluvium of the Great Western Plains, the agricultural conditions become less favourable and wheat is wholly replaced by sheep. South of the Blue Mountains the elevated region of New South Wales narrows greatly until near Goulburn the 2,000 foot contour is only 20 miles wide. At this col the southern railway crosses towards Albury and Melbourne, while (as in the northern col at Murrurundi) a second railway ascends the Highlands and, proceeding south, reaches Cooma some 50 miles from Mount Kosciusko. This southern col is geographically very interesting. It is partly due to extensive faults and folds, probably allied to the Blue Mountain monocline fold behind Sydney. Lake George—the largest lake in New South Wales—which in 1880 was 17 miles long and nearly 30 feet deep, though in 1907 practically dry—occupies a fault valley[1] on this col (see Fig. 20).

[1] See the *Proceedings of the Linnean Society of New South Wales*, 1906 and 1907, for three papers (by Taylor, Woolnough and Taylor, and Taylor) dealing with the geography of this district.

A long ridge divides the Shoalhaven river from the upper waters (Wollondilly) of the Hawkesbury. It has been shown that the upper Shoalhaven ran into the upper Hawkesbury at an earlier stage in its history, though now it turns abruptly to the east and flows through deep gorges directly to the sea. The upper Shoalhaven, draining limestones and slates of older palaeozoic age, is noted for its alluvial and reef gold, Braidwood (Br.) and Araluen being the chief mining centres. It is interesting that the bed of the ancient junction of the Wollondilly and Shoalhaven—now 1,500 feet above the Shoalhaven—has also been profitably worked as the alluvial diggings of Barber's Creek.[1] The basalt cappings on this watershed near Moss Vale have formed a rich soil which supports a large farming population amid the somewhat barren areas of trias sandstone.

The Kosciusko Massif.

The Kosciusko Massif (see Fig. 20) extends south from the Goulburn gap to beyond the Victorian border. It almost reaches the coast and is about 100 miles wide. It is drained on the north by the Murrumbidgee and on the south by the Snowy river. Cooma, on the divide between these river-basins, is the chief town and is the railway terminus for tourists to the alpine district of Australia around Kosciusko. At Kiandra are large alluvial diggings, and its great elevation (4,640 feet) leads to a heavy snowfall, so that 'for many months of the year the people, young and old alike, go about on snow shoes' (J. M. Taylor). The massif terminates in the granite boss of Mount Kosciusko (7,350 feet), the highest mountain in Australia. Here is a true Alpine country ('The Monaro') where snow lies on the sheltered slopes almost

[1] *Proc. Linnean Soc. N. S. W.*, 1906, p. 548.

all the year, and where the ancient glaciers have left huge piles of transported blocks (moraines) and scooped out the pretty lakes and tarns which fringe the main ridge. Except on the south-west, Kosciusko is not at all rugged, as may be realized from the fact that a motor route was constructed in 1908 to the top by gangs of 'unemployed', from whom, alas, Australia is not free. Many years ago a bullock dray carried up material for an Observatory on the summit, which has, however, been abandoned; and though an increasing number of tourists visit this land of flowing brooks—so rare in other portions of Australia—yet the uplands of the Monaro are chiefly inhabited by cattle.

Two of Australia's chief rivers flow down the western slopes of the Kosciusko massif. In many ways is the Murrumbidgee river interesting. One of its tributaries, Umeralla Creek, rises south-east of Cooma, less than 40 miles from the coast, and is 20 miles nearer Cape Howe than the Indi or Upper Murray. The State of Victoria in 1851 was defined on the north-east 'by a straight line drawn from Cape Howe to the *nearest* source of the River Murray. One can hardly blame one section of the Victorians for claiming that the portion of New South Wales—including most of the Riverina—south and west of the Murrumbidgee, by the terms of this Act should belong to Victoria! The Silurian limestones of the Upper Murrumbidgee are rich in picturesque caves which attract many visitors, and the route from Tumut by the Yarrangobilly Caves and Kiandra to Kosciusko and thence to Cooma is deservedly popular with Australian tourists.

Where the country becomes less rugged, numerous small towns have arisen, such as Queanbeyan and Yass—and it is near the latter that the future capital of the Commonwealth is to be built. The site is close to the Inter-State railway from Sydney to Melbourne, being about 200 miles from the former, and 400 from the Victorian capital. Of greater interest to the student of economics is the Barren Jack Dam which is now being constructed across the Murrumbidgee, 20 miles south-west of Yass, where the river passes through a gorge several hundred feet high. A depth of 200 feet of water could be obtained, and the total capacity would be very nearly equal to that of the Assouan dam on the Nile. This work is discussed in the section dealing with irrigation (Chapter XVII).

The Victorian Highlands.

The southern division of the Cordillera consists of the Victorian Highlands (see Fig. 21), which run from west to east, of which the chief group consists of the granite masses extending in a line from Glenelg to Kosciusko to the north of the present divide, which is formed in ranges of sedimentary rock running north and south. These diverse elements have been eroded to a more or less uniform level or *peneplain* (i. e. almost a plain) and re-elevated. The mountainous parts of Victoria are mainly formed by broad areas of old peneplains which are again being cut down to another base level by rivers whose erosive action has been renewed by the general uplift of the whole country. Professor Gregory has called the granite belt the Primitive Mountain Chain. Eastern Victoria contains the greatest number (16) of peaks over 5,000 feet in the Eastern Highlands, such as Hotham (6,100), Feathertop, so called from its snow cap (6,300), and the Bogongs (6,500), while Kosciusko, in New South Wales, is only 10 miles over the border. This portion of Victoria is composed chiefly of granite and old palaeozoic rocks, so that it is rich in mineral wealth. South of Albury there is a flourishing gold-mining district around

Beechworth; while Yackandandah is noted for the method of winning gold by means of suction dredgers, which suck up the alluvial from the river bed. It is from this district that it is proposed to irrigate the drier north-west portion of Victoria by means of an irrigation canal from the Upper Murray.

The upper waters of the Mitta Mitta, Ovens, and Goulburn flow through a rugged country in which farming is carried on successfully on the fertile soils of the river flats. The Ovens river district has the heaviest rainfall (44 inches) in Victoria, which becomes gradually drier towards the north-west as the highlands give place to the flat plains (Wimmera), which are due to the elevation above sea level of the ancient Murray gulf.

The central portion of the Victorian Highlands contains the best-known gold-fields in Australia. The four gold-fields of Bendigo (north), Ballarat (south), Castlemaine (east), and Maryborough (west) form a sort of 'Southern Cross' 60 miles long, from which seventy per cent. of the Victorian gold is derived. Bendigo is noted for its 'saddle reefs', which ensure permanency of yield to a greater extent than the more usual 'fissures veins'. The slates have been folded so as to form Λ shaped spaces at the apices of the upfolds (anticlines), and these have been subsequently filled in with auriferous quartz. Other quartz masses of a similar shape are generally found more or less perpendicularly below the first, and so the deposits somewhat resemble a pile of saddles one below the other. At Ballarat the well-known 'indicators', or regular bands of carbonaceous shale, show the richest portions of the quartz reef, since at their intersection a deposition of gold often occurs. This ore-deposit is described in detail elsewhere (pp. 177–8). But the district is by no means dependent on mining, for a great portion is cut up into prosperous farms, and indeed in most of the modern 'rushes' the neighbouring farmers have been the first in the field and naturally secured the best claims.

It is necessary to emphasize the plateau-like character of the Western Victorian Highlands. They are really stumps of old mountain ranges of various ages of elevation all of which have been rounded and flattened by long-continued erosion. The Pyrenees, between Ballarat and Ararat, are relics of the Primitive Mountain Chain which is flanked by alternating basins and plateaus rather than by ridges and narrow valleys. Basalt is common and its disintegration, which is more thorough and yields richer phosphate contents than do granites, enriches the plains on lower levels. Ararat is the chief town in this western area, and is rich in gold mines, wheat, and vines.

Summarizing the physiography of the Victorian Highlands, one notes that the eastern portion is higher, more rugged, and has a heavier rainfall. Hence it is that the population curve bulges to the less rugged west as shown on the sketch-map (Fig. 21). Gold-mining is carried on throughout the Highlands, but the chief centres are around Ballarat and Beechworth. The drier, warmer western portions are more suitable for wheat and vines.

Tasmania.

There remains one well-defined area, undoubtedly a part of the Eastern Highlands, both geologically and biologically. The island of Tasmania is about the same size as Scotland, the width and length are both approximately 200 miles. Bass Strait, which separates it from the mainland, is 150 miles wide. 'An elevation of 300 feet would lay dry a tract of comparatively level country between Victoria and Tasmania, rising to a central ridge on the eastern side.'[1] It seems certain that this isthmus has been broken since pliocene times, for in the Beaconsfield gold-field (C in Map and section) fossil fruits of this age were found at the bottom of an ancient river valley, which is now many feet below the present deepest part of Bass Strait. A river cannot erode its bed below sea level, so that the land must have been relatively 270 feet higher when the pliocene river (shown at C in the section) deposited the fruits. Mr. Hedley[1] has shown that the marine fauna varies largely on each side of Tasmania, and has not yet completely mingled by way of the Bass Strait. The granite islands and masses shown in the map, extending from Kosciusko to Freycinet Peninsula, are the remains of a primitive mountain chain analogous to that running through Victoria, so that the evidence linking Tasmania with the cordillera region is very strong.

The broad features of the structure of Tasmania are fairly simple. The island consists chiefly of older palaeozoic strata such as build up the Victorian Highlands. These have been penetrated by granite masses (see section, Fig. 23) which on the east constitute the mountain axes we have mentioned, and in the north-west build up Mount Bischoff, Mount Zeehan, and Mount Lyell, which are world-renowned mining-fields. Their mineral wealth is probably due to the interaction of the granites and sediments. During the time the coal measures were accumulating in the New South Wales basin, a similar basin in Tasmania was being filled with marine sediments. Its axis extended in a north-west direction from Hobart, and it probably covered Central Tasmania. Profitable seams occur in isolated deposits, such as the Tasmanites, shales and coal of the Mersey basin in the north. Somewhat later deposits of much greater value occur at Mount Nicholas in the north-east. But the most

[1] *Proc. Lin. Soc. N.S.W.*, 1903, p. 878.

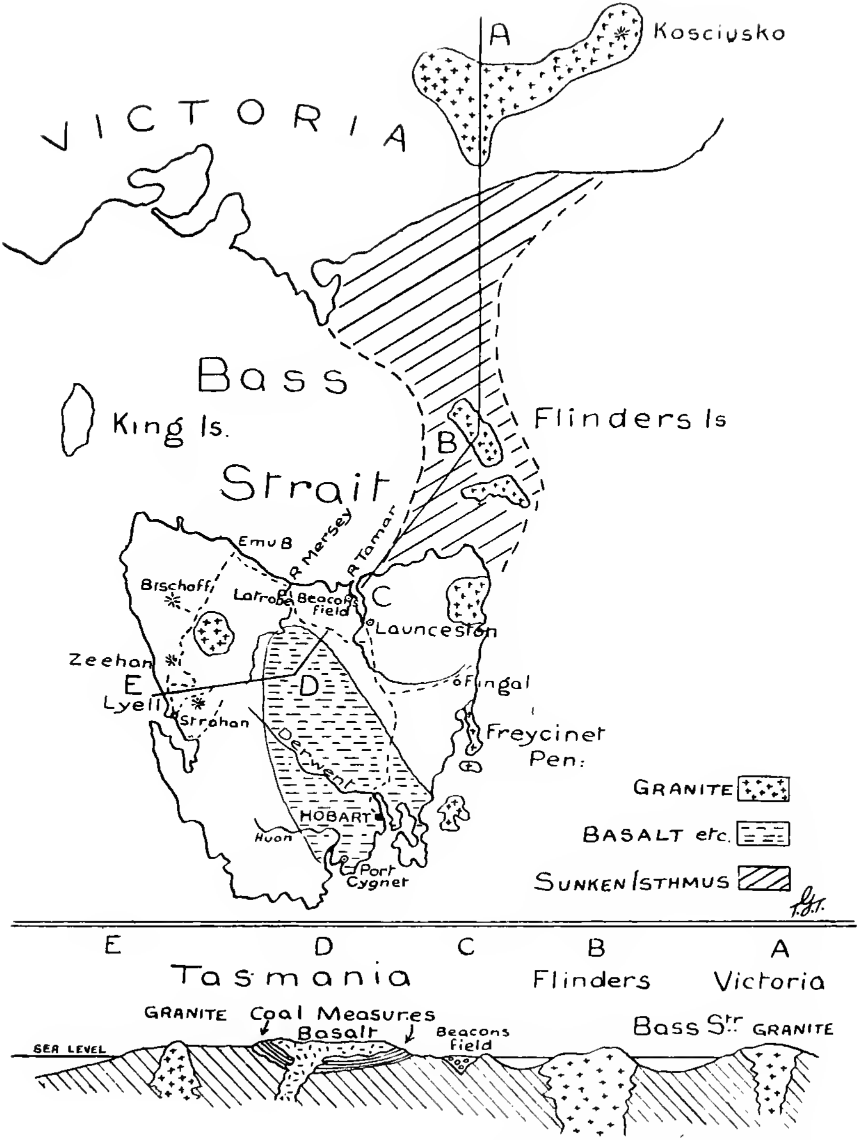


FIG. 23. Tasmania. Geological Conditions. Showing the sunken isthmus; and below a section along the line A–E. (Chief railways as broken lines.)

striking features in the geology of Tasmania are the huge sheets of basalt or allied rocks (see section, Fig. 23) which have practically covered one-third of the island, including most of the coal basin, and form part of the 3,000 foot tableland of West Tasmania.

A line joining Hobart to Emu Bay in the north-west separates approximately the extremely rugged western district from the fertile and prosperous eastern portion. The chief railway connects Hobart, the capital, with Launceston, the northern capital, and passes through a country which has often been compared to England, though its latitude is rather that of the Riviera. (The Southern Hemisphere is, however, in general cooler than the Northern.) Tasmania is the sole Australian State blessed with an abundant rainfall. Indeed, the western portion has considerably more than 40 inches a year, due to the constant Westerlies rising over the tableland, and as the evaporation is not great, this is much more than is economically required. Here occurs the curious 'Horizontal Scrub[1]', a tangled mass of boughs forming a kind of platform 30 feet from the ground. The dense growth of the western jungles, for such they are, though in a temperate region, prevented the opening up of the west until the Mount Bischoff tin mines were discovered in 1871. For some time these mines yielded fabulous returns, especially after a tram line had been laid to Emu Bay. Thirty miles south the equally famous Mount Zeehan silver-lead mine was discovered in 1882, while in 1886, perhaps the richest district of all, Mount Lyell, was opened up, and now boasts that it is the largest copper mine in Australia. These famous mines are connected by a railway with Emu Bay on the north and Strahan on the west coast. In 1906 Zeehan produced silver-lead worth £500,000,

[1] *Anodopetalum biglandulosum*; see G. Smith, *Naturalist in Tasmania*, 1909.

Mount Bischoff tin to the same value, and Mount Lyell copper to the value of £800,000.

The area of Tasmania is only 1 per cent. of the whole Commonwealth, and this fact, combined with the rugged and wet character of the western half, has resulted in fewer sheep being raised than might have been expected from the situation of the island. The flocks of the mainland are regularly recruited from the cooler uplands of Tasmania, but the number of head has not altered since 1860, being about 1,750,000. They are most numerous around the Tamar and the rivers running into it. It is recognized that Tasmania is pre-eminent in Australia as a fruit and vegetable-growing country. In 1902, for instance, the value of the fruit and potatoes exported was double that of wool, reaching £700,000. The chief orchards lie around the capital, Hobart, while tons of potatoes are grown annually in the rich soils along the north coast to the west of the River Mersey.

Coal occurs in two main formations, the newer (jurassic ?) measures around Fingal (in the east) yielding excellent steam-coal, while the carboniferous coals occur at Latrobe and Port Cygnet and elsewhere, the southern locality having a fair seam which is not, however, comparable with those of Fingal.

CHAPTER VIII

THE CENTRAL LOWLANDS AND THE HIGHLANDS RISING OUT OF THEM

Between the Eastern Highlands and the Western Tableland lie the Central Lowlands. This area is conveniently divided into the Murray-Darling Lowlands in the south-east, the Artesian Lowlands in the centre and north, and the Cambrian Highlands and the Rift Valleys in the south-west.

The Murray-Darling Lowlands.

This is an approximately square area some 400 miles wide, and lies chiefly in New South Wales. The boundaries are fairly well defined on the south by the Victorian Highlands, on the west by the Cambrian Divide, and on the east by the Kosciusko and Blue Mountain Highlands, but on the north the southern boundary of the Great Artesian basin is not apparent from surface features. It has been mapped from borings, and runs along the Rivers Bogan and Darling to Bourke, and thence in a general westerly direction past the Cambrian Divide to longitude 133° in South Australia.

There is no striking difference in the characteristics north or south of this admittedly arbitrary line except that the northern portion has an artesian water supply which is wanting south of the Bourke-Bogan line. Yet the Murray-Darling Basin is a fairly homogeneous geographic entity which can be most satisfactorily considered apart from the remainder of the Central Lowlands.

There are three fairly distinct subdivisions which are

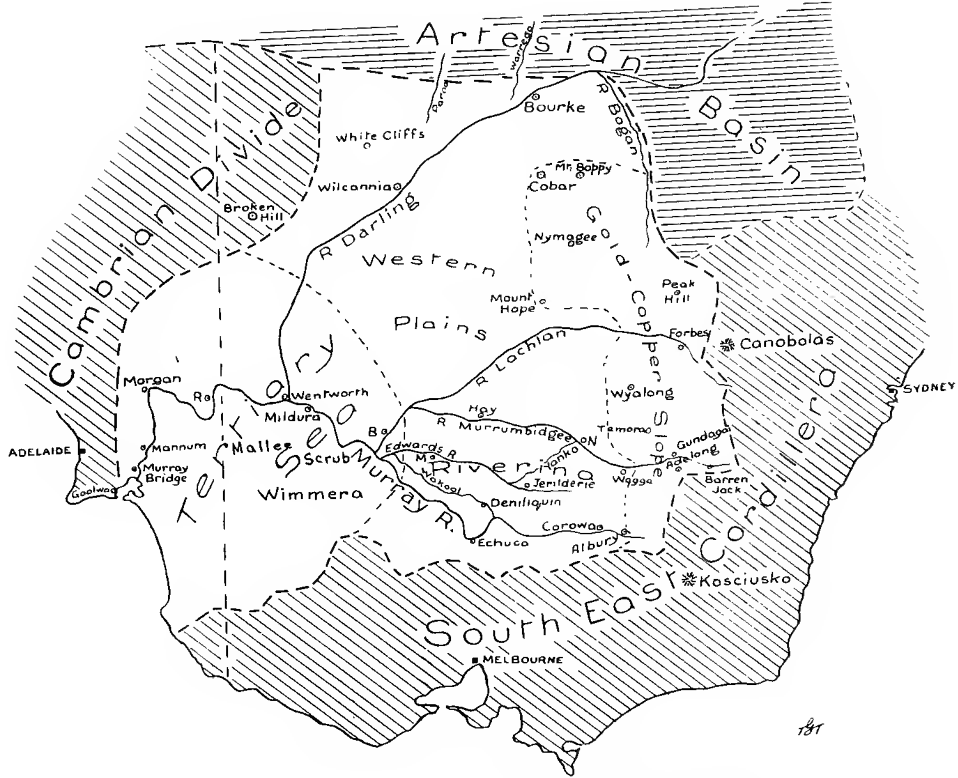


FIG. 24. The Murray-Darling Lowlands and their Subdivisions.

shown on the sketch-map (Fig. 24). (1) On the east is what may be termed the gold-copper slope of New South Wales, (2) in the centre are the Western Plains, whose southern portion is known as the Riverina, while (3) in the west is a large area of tertiary deposits which represent the elevated sea-floor of a broad estuary.

The Gold-Copper Slope.

Dealing first with the Gold-Copper Slope of New South Wales, it consists of the foothills of the Eastern Highlands, the eastern portion being some 1,500 feet high, and gradually sloping down to the Western Plains which reach the 500 contour line. As explained in a later section the old palaeozoic sediments of the Eastern Highlands, and its foothills are buried below the river soils and gravels of the Western Plains, but islands (inliers) of such old rock project at Mt. Hope and elsewhere and contain many rich copper and gold deposits. The chief mining-fields are Cobar, Mt. Boppy, Peak Hill, Nymagee, and Mt. Hope, north of the Lachlan, and Forbes, Wyalong, Temora, and Adelong, south of the Lachlan.

A large portion of this tract is within the wheat belt, but sheep are also largely pastured.

The Western Plains of the Murray-Darling Basin.

It is in the central division, the Western Plains, and especially in the Riverina between the Murray and the Murrumbidgee, that great irrigation developments are to be expected. Wheat grows well in the south-east. The quantity of rain falls off rapidly to the west, which is irrigated from the head waters of the Victorian rivers and in New South Wales will be irrigated by the Barren Jack scheme, which is described in detail on pp. 165-6. There is practically no mining, except for opal in the cretaceous sandstones at White Cliffs in the north-west, and except for wheat in the south-east, little agriculture. The whole country is given over to the merino sheep; and the cattle are gradually moving away north. Of the rivers of this area by far the largest is the **Darling** which is some 3,282 miles (Russell) from its source to its junction with the Murray. In the south it dwindles to a series of water-holes during drought. Nearly all its water comes from Southern Queensland, for from Bourke to Wentworth, nearly 500 miles, it receives no tributaries; the Warrego and Paroo entering the main stream only during heavy floods. Bourke, the terminus of the Western Railway from Sydney, is a pastoral centre. Wilcannia is a river port collecting wool and mineral products which steamers carry to Mannum (South Australia), Goolwa (South Australia), or Echuca (Victoria), for transhipment to Adelaide or Melbourne.

The **Murray** itself is, however, much the most important stream, though only half the length of the Darling. It is fed by the snows of the Australian Alps and is the only river of the whole system which has never been known to cease running in dry seasons. It rises near Mt. Kosciusko and forms the boundary between New South Wales and Victoria until Renmark (R. on Fig. 24) is reached, from near which it flows across land which is wholly South Australian.

Albury, about a hundred miles from its source, is situated where it enters the plains. Corowa and Wahgunyah are twin towns through which a large portion of the trade of the Riverina passes to the capital of the southern State. The 'deep leads' or alluvial gold buried under ancient lavas extend beneath the Murray here and have yielded much gold. Wheat and vines grow well in the district.

The red-gum timber is largely exploited between Corowa and Echuca, and grows only along the river belt. The latter town is an important river port and receives wool from the Darling and lower Murray for transport to Melbourne. Here a private railway enters New South Wales and taps the Riverina as far as Deniliquin, the traffic being thus diverted to Melbourne. Indeed Melbourne is the natural outlet of the district south of Wagga, which town is roughly equidistant from Melbourne and Sydney.

The chief tributaries of the Murray, other than the Darling, within the Western Plains, are the Lachlan, Murrumbidgee, and Edwardes.

The **Lachlan** drains the rich gold-mining country around Forbes and Temora already described. In summer it usually becomes a chain of water-holes, but a water conservation scheme now under consideration will, if carried out, vastly increase the resources of the land along its banks. These black soil plains are derived partly from the basalt hills of the Canobolas Mountains and are very fertile when sufficient moisture is available.

The **Murrumbidgee** is a finer river than the Lachlan, and having a more constant water supply does not cease running so early. After leaving Gundagai it flows through flat plains known as the Riverina, which extend southwards to the Murray. Several ‘billabongs’ (Yanko, Wakool, &c.) connect the two rivers long before their junction near Balranald is reached. Some of the billabongs may be over a hundred miles long (i.e. the Edward), and a local flood in the Murray may cause the water to flow *up* these billabongs for many miles. Wagga, Narandera, and Hay on the Murrumbidgee, Jerilderie, Deniliquin, and Moulamein on the billabongs, are all towns chiefly devoted to wool, though wheat is largely grown in the eastern districts of the Riverina.

The Tertiary Area of the Murray-Darling Basin.

The third subdivision of the Murray-Darling area is the large extent of tertiary deposits which fill up the gulf into which the Darling, Murrumbidgee, and Murray once flowed by separate mouths. Except in the south-east this region is very dry, and settlements occur only along the Murray River, which plays the part of the Nile. Below Echuca this river is navigable at all seasons, but few towns of importance lie on its banks. Mildura in Victoria, near the junction of the Murray and Darling, is an irrigation colony where over a million has been spent on clearing land, pumping, &c. Wentworth is advantageously situated at the junction of two big rivers, and is an important river port whence wool is shipped to the railway at Morgan in South Australia. Agriculture, except by irrigation, is impossible, since the rainfall is only 10 inches. The Renmark Irrigation Works (R. on Fig. 24) in South Australia support seven or eight hundred agriculturists. Several thousand acres watered by pumping from the river are planted with vines and fruit trees, and this oasis seems to be flourishing. Morgan, already mentioned as connected by rail with Adelaide, is situated where the Murray makes a sharp bend to the south. For the remainder of its course no towns of note except Murray Bridge, where the Interstate Railway crosses the river, are passed.

The outlet to the southern ocean of this huge river system—whose north-east limit is a thousand miles away—is a large, shallow lagoon, separated from deep water by shifting sand banks which prevent navigation by any but the smallest steamers.

Enclosed within the rectangular course of the lower Murray is an area of lowlands, extending towards the Victoria Highlands, with a rainfall gradually increasing to the south-east from 10 to 20 inches. Portions of this country are found to grow good wheat when cleared of the stunted gums which constitute the well-known 'Mallee Scrub'. The rivers, which rise in the Grampians, do not in general reach the Murray, but lose themselves in the Mallee. The north-west portion of Victoria is known as the Wimmera District and is traversed by belts of good country which will undoubtedly be of great value when the water conservation schemes are fully developed.

Summarizing the geography of the Murray-Darling basin, it can be divided into (*a*) an *eastern* portion rich in gold and copper, and growing wheat where the rainfall exceeds 20 inches; (*b*) a *central* portion of plain country devoted to merinoes, but with wheat in the south-east; and (*c*) a *south-west* portion, of which a large part near the Murray is an arid, undeveloped district, though irrigation colonies occur at Mildura and Renmark. The southern portion of the Wimmera District in Victoria is, however, a flourishing agricultural district watered by the upper Wimmera and its tributaries.

CHAPTER IX

THE SOUTH AUSTRALIAN (OR CAMBRIAN) HIGHLANDS AND THE RIFT VALLEYS

The Cambrian Highlands.

THIS is a well-defined geographical region consisting of the area of highlands between the Murray Basin and the Great Tableland of Australia. Not only is it of a totally distinct nature geologically from the rocks constituting the Tableland, but it is separated from the latter by a great

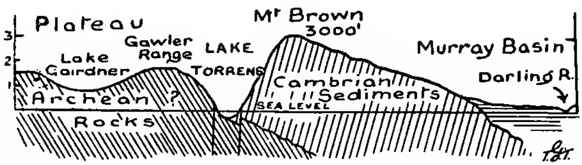


FIG. 25. Section across the Cambrian Divide, about the Latitude of Lake Torrens, showing the Rift Valley occupied by the latter Lake.

depression or trough which, in Professor Gregory's opinion, constitutes a rift valley. Lake Torrens and Lake Eyre are both below sea level, while Spencer's Gulf—one of the most important of the few gulfs penetrating the continental mass—is probably related to Lake Torrens in much the same way as the Gulf of Akaba is to the Dead Sea in the Jordan–Red Sea rift (see Fig. 25).

The main divide of these highlands lies somewhat to the west, culminating in Mount Lofty (near Adelaide, 2,334), Mount Razorback (near Burra, 2,834), and Mount Brown (near Quorn, 3,100) (see Fig. 26). None of the rivers are of importance, and in the north the water supply is obtained chiefly from wells sunk in the beds of the intermittent rivers.

The lakes are all shallow sheets of salt water, and worthless from an industrial point of view. After heavy rains Lake Frome is joined to Lake Eyre, forming a temporary cordon of water which is marked on old maps as a vast horseshoe lake.

The geological factors mentioned above have led to an industrial isolation from the surrounding regions of a somewhat marked character. The Cambrian Highlands (including the Mount Lofty and Flinders Ranges) lie in the course of the strong westerly winds in winter. They have therefore a better rainfall (see Fig. 26). The main settlement in South Australia has accordingly taken place from Beltana to Eyre Peninsula on the west and to Morgan on the east. The chief industries in the State are wool-growing (£2,000,000), wheat-growing (£3,000,000), copper-mining (£750,000), and wine-growing (£125,000), and with the exception of a portion of the wool, almost all these products are obtained from the Cambrian Highlands or the districts bordering thereon. The heaviest rainfall occurs round Adelaide on the slopes of the Mount Lofty Ranges. Here the vineyards are planted whose wines are becoming favourably known all over the world. Clare and Tanunda are two of the most famous cellars, both being to the north-east of Adelaide.

The ancient slates and limestones constituting this Cambrian area are much folded and have been penetrated by ore-bearing thermal waters. The mines at Moonta and Burra (80 miles north-west and north-east respectively from Adelaide) were once the chief sources of copper in Australia. The former is still very important, and copper 'shows'

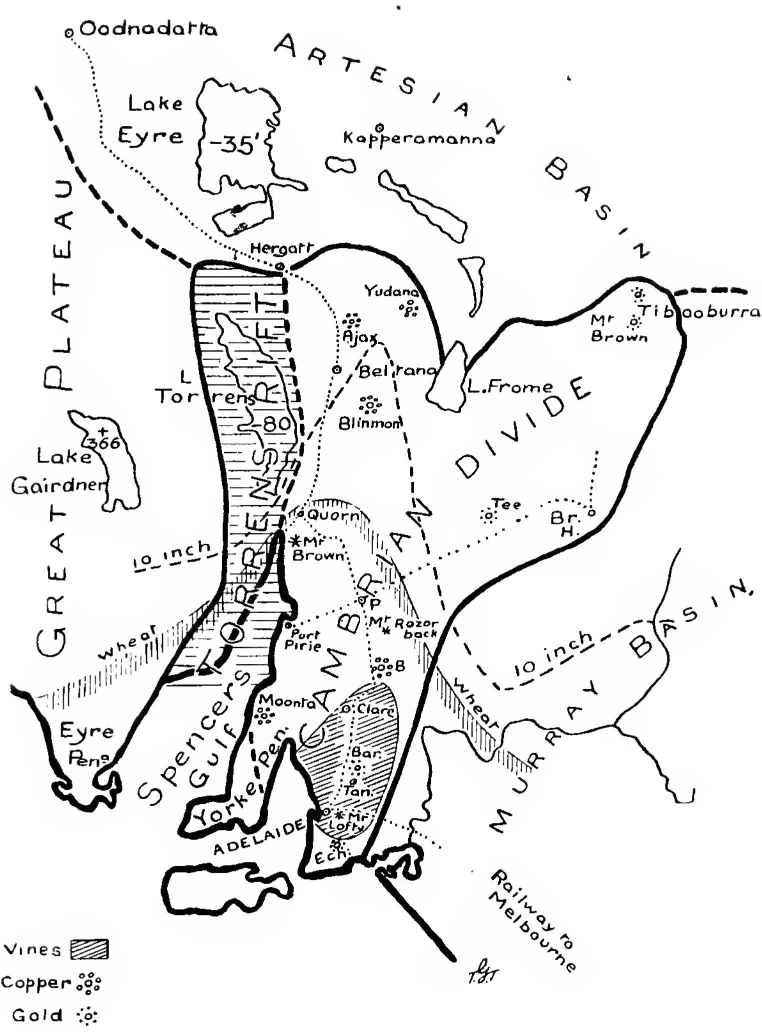


FIG. 26. The South Australian or Cambrian Highlands and the Torrens Rift Valley.

occur throughout the Cambrian area. Gold has not been of much importance, for South Australia produces less than 1 per cent. of the Australian yield. On the eastern edge (in New South Wales) is the phenomenally rich silver-lead-zinc deposit of Broken Hill. Excluding the capitals, this town is the fifth in Australia, although situated 200 miles from the coast in a desert region with less than 10 inches of rainfall per annum. The mine and its environment are discussed in a later section (pp. 173–6). North of Broken Hill are two gold mines in the same formation, at Tibooburra and Mount Brown. Apart from mining, there is little profit in this arid tract, though sheep-rearing can be carried on successfully on large stations where each sheep can be given a wide enough grazing-ground—say 40 sheep to a square mile.[1] It is not the direct lack of water so much as the lack of food during drought which decimates flocks.

It is to wheat, however, that South Australia chiefly owes her prosperity. The wheat line coincides fairly accurately with the 13 inch isohyet (see Fig. 26), the rain falling chiefly in those months when it is most needed, so that the total supply, though low, is sufficient. The three peninsulas, Eyre's, Yorke, and Mount Lofty, are included in this area and produce perhaps the best selling wheat in the world. So also the 20 inch isohyet bounds the chief viticultural area, while the 10 inch isohyet is the limit of economic wool-growing, except in the case of extremely large holdings where expensive water conservation can be undertaken.

[1] D. J. Gordon, *The Central State*, p. 44, gives valuable figures in this connexion.

The Torrens Rift Valley.

This district is of practically no industrial importance except at the head of Spencer's Gulf, where two flourishing ports, Port Augusta and Port Pirie, are situated. Port Augusta has a fine harbour where the products of the northern portion of South Australia proper are shipped. Wool, wheat, and copper ore, as might be expected, are the chief exports. Some gold from Tarcoola is also shipped here. It is interesting to know that a large ostrich farm is thriving in the vicinity.

Port Pirie is the second town in South Australia, the population being largely engaged in smelting the Broken Hill ores. During the wheat season immense quantities are shipped at this port.

The inland portion of this area is arid and undeveloped.[1]

[1] The physiography of this barren region is briefly described in Gregory's *Dead Heart of Australia*.

CHAPTER X

THE ARTESIAN REGION

A WELL-DEFINED geographical region of Australia is coincident with the Artesian Region. It may be divided into two parts (see sketch-map, Fig. 19) which may be termed for convenience of reference the Lake Eyre Division and the Eastern Division. The boundary between these two areas almost coincides with the 10 inch isohyet, so that one may broadly term the Lake Eyre Division the Desert moiety and the Eastern Division the Pastoral moiety.

The geological structure of this region being discussed at some length in a later section (Chap. XV), it will be sufficient to remark that it consists largely of a series of soft sedimentary rocks, capped occasionally by harder barren sandstones—the Desert Sandstone.

The Eastern or Pastoral Artesian Region.

The Eastern Division extends some 1,200 miles from the Gulf of Carpentaria to Dubbo on the Macquaric River in New South Wales, and is about 300 miles wide.

The northern portion around the Gulf consists of a low-lying country—probably the elevated bed of the gulf adjacent—with a rainfall of 20 to 40 inches. It is watered by numerous rivers. Normanton, the chief town, is partly supplied with water by an artesian bore. Behind the mangrove swamps of the northern margin is an important cattle-grazing district. The chief industries are, however, connected with mining, much gold being obtained at Croydon and copper at Cloncurry. These ore deposits occur in 'islands' of older rock, projecting through the artesian water-bearing strata.

To the south of this Gulf country the land rises considerably, and a strip of about a thousand feet above the sea extends south to the head waters of the Paroo and other northern tributaries of the Murray, whence it gradually slopes down to 500 feet along the southern boundary of the artesian basin. It is important to note that this portion of the Artesian Basin lies almost wholly in the 10 to 20 inch rainfall area, so that except in the south, where some wheat is grown, there is nothing to compete with the pastoral industry. Hughenden, Winton, Barcaldine, Charleville, and Cunnamulla are all centres of sheep and cattle districts connected by railways to one of the ports, Townsville, Rockhampton, or Brisbane.

The northern portion of New South Wales is included in this artesian area. Here, in addition to pastoral products, large quantities of wheat are grown round Narrabri, Moree, &c., and indeed as far north as Roma, in latitude 26° 36′. In the whole of this large area almost a thousand artesian bores have been drilled and are of immense value for watering stock, though it is doubtful if they are an economic source of water supply for irrigation. This question is, however, discussed in Chapter XV.

The Lake Eyre Basin or Desert Artesian Region.

The remaining division of the Artesian Basin comprises the lowlands drained by the rivers Diamentina, Barcoo, &c. The lowest portion of the area constitutes Lake Eyre of which the southern arm usually contains salt water, while the remainder is a vast salty plain formed from alluvium carried down by the large rivers which now enter it only in flood time. It is situated within the 10 inch isohyet, and though many pastoral areas have been occupied, almost all are now deserted. Professor Gregory has named this region graphically and forcibly, 'The Dead Heart of Australia.' His book gives a clear picture of the region at midsummer, while the writer found in February, 1906, the same conditions of terrific heat and deserted sheep-runs.

During good seasons, such as those of the eighties, this area (150,000 sq. miles) can support thousands of sheep, but it is difficult to see how the inevitable period of dry seasons can be tided over. The artesian water supply will not prevent the shortage of food, such as saltbush and blue-bush, and conservation of flood waters in this level area on any large scale is almost an impossibility. Moreover, drought is the rule rather than the exception, and as the more northern districts of the territory appear to be much better country it seems probable that the Lake Eyre Basin will be one of the last regions of Australia to repay settlement. Since the geological formation is late mesozoic there is little likelihood of valuable mineral deposits being discovered, since such usually occur in palaeozoic rocks.

Opals occur in the east near Winton (Queensland) and at White Cliffs in New South Wales, but the huge desert settlements of Broken Hill (silver-lead) and Kalgoorlie (gold) can never be paralleled in the Lake Eyre Basin.

Professor Gregory has disposed of the project to increase the rainfall of this region by filling Lake Eyre with sea water. It is 39 feet below sea level, but the necessary canal (260 miles long and probably 1,100 feet wide and 100 feet deep) would cost, it is calculated, about £740,000,000. Moveover, it is probable that in thirty years the whole lake bed would be choked with salt derived from the evaporation of the sea water!

The value of the artesian water in keeping open the great stock routes is discussed in a later section (pp. 144–6).

CHAPTER XI

THE WESTERN TABLELAND

THE last physical region with which we have to deal is much the largest. It comprises about 54 per cent. of the island and includes the whole of Western Australia and most of South Australia, except those portions of the latter state which have already been described under the heads of the Lake Eyre Basin and the Cambrian Highlands.

This vast region is by no means so important economically as the Central Lowlands, and only supports about 6 per cent. of the population (250,000 out of 4,000,000). It consists of an enormous area of very ancient rocks (such as gneisses, schists, and quartzites), which are probably of pre-palaeozoic age. They form a plateau about 1,000 feet in height, relieved by a few higher belts, the chief being the MacDonnell Ranges in the centre of the continent, and King Leopold Range in the Kimberley district. No rivers water the interior, but along the coast, especially in Northern Territory, there are several fine waterways, such as the Roper and Victoria.

It will be recognized that there are no dominating physical features to assist subdivision of the large area, except it be the Central Highlands in the east, which form one division. Since this tableland extends through almost 25° of latitude it is obvious that it is subjected to very different meteorological conditions. Accordingly the most satisfactory divisions are the south-western temperate region, the north-western tropical region, and the central desert with its enclave the Central Highlands (see Fig. 27).

The North-Western or Tropical Tableland.

The northern tropical region extends from the Gulf of Carpentaria round to Shark Bay on the west, and has

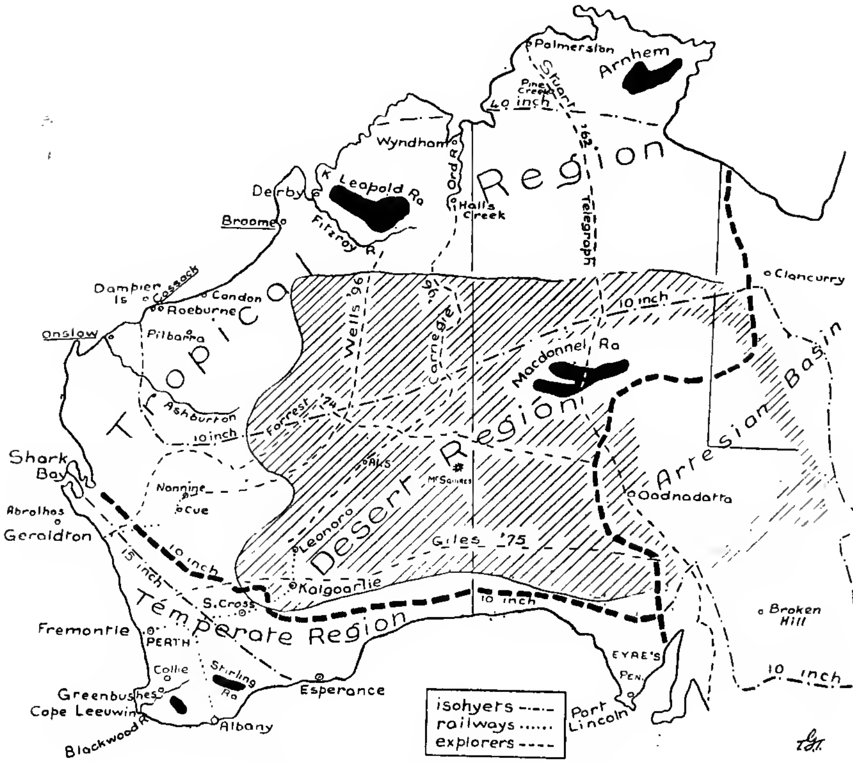


FIG. 27. The Western Tableland Region.

an average width of about 400 miles. The towns in this vast territory number about a dozen, being with very few exceptions either settlements around the stamp batteries on a gold-field, or ports leading to them.

In Northern Territory three industries occupy all the inhabitants, of whom less than nine hundred are European. These are gold-mining (exports 1902, £70,000), cattle rearing (£70,000), and pearl-shelling (£20,000). The coast is low and flat, and 100 miles inland at Yam Creek it is only 300 feet high. Still farther inland there is a series of low ranges which do not exceed 1,000 feet, though they are extremely rugged. There are higher elevations in the little-known Arnhem Land.

These low ranges contain the mineral deposits which give employment to several hundred Europeans and several thousand Chinamen. D. J. Gordon, in his book *The Central State*, is courageous enough to oppose the White Australia policy in the following words (p. 226):—'With a soil capable of producing on a commercial basis such products as sugar-cane, rice, maize, linseed, oil-plants, tea, coffee, indiarubber, tobacco, cotton, millet, and coco-nuts; a rainfall that can be measured in feet, and no lack of sunshine; the Northern Territory continues to be a nightmare to Australian statesmen and a geographical enigma to the rest of the world. White men who have lived and worked there are unanimous in declaring that only the coloured races can develop the resources of tropical South Australia. . . . Southern Australia has declared for a White Australia, and until there is some modification of that policy Northern Australia must continue to remain an unoccupied paradise of vegetable vitality and tropical luxuriance.'

It is of interest to compare this tract with another of similar character and latitude where white labour is being used successfully—i. e. the Isthmus of Panama. Here much of the manual labour is done by whites—not by Anglo-Saxons, however, but by Spaniards and Italians. The Australian Labour Party have less objection to these descendants of Imperial Rome than they have to the coloured man, whether yellow or black, and possibly in the future they may be encouraged to settle here. Dr. Holtze estimated that some 80,000 square miles of the coastal strip (80 miles wide) is suitable for tropical plantations. Probably, however, cattle and horse rearing will be the main industry other than mining—for many years to come. There is certainly very good land available for this purpose in many portions of the hinterland, especially around the head waters of the Victoria River in the west, and from the head of the Roper to Camooweal in Queensland. In 1902 there were about 306,000 cattle, 15,000 horses, and 42,000 sheep in the Territory, obviously not a tithe of those which the country could support, judging by the distribution in Queensland, where a somewhat similar area between the same rainfall lines gives food for three million cattle, half a million horses, and fourteen million sheep. A railway 145 miles long connects Pine Creek and Palmerston, and thence the overland telegraph runs south through good cattle country for 400 miles.[1]

In Western Australia somewhat similar country occurs as far south as Shark Bay, where conditions more favourable to white settlement commence. All along this coast pearl-shell is obtained; the head-quarters of the fleets being at Broome, Roeburne, and Condor (see pp. 208–10). Another profitable undertaking is the gathering of guano, chiefly from the Lacepede, Dampier and Abrolhos Islands.

The coastal plain is wider at the mouths of the Ashburton and Gascoyne Rivers, but no important agriculture is carried on north of Shark Bay. Several well-defined gold-fields occur in this division. One of the most im-

[1] In the Magazine *Life* (published in Melbourne) for March, 1907, there is a map of the Northern Territory in which the district north of 20° is given as good pastoral country.

portant is Kimberley, which lies in the north of the State in the hilly country (King Leopold Ranges) dividing the basins of the Fitzroy and Ord Rivers. Hall Creek is the chief centre and is reached via Derby or Wyndham. The whole population is less than a thousand, though numbers of cattle and sheep are raised here also. Near Derby is Broome, where the cable from Java is landed. It is an important pearling centre, a large cattle-port and the chief town in the north-west.

To the south, across the western fringe of the Great Sandy Desert, is the Pilbarra Goldfield. Here again the mines are scattered, Marble Bar being the chief centre. They are reached from the ports of Cossack and Condon. Sheep are more plentiful in this district, especially near Roeburne and Onslow.

The southern 10-inch annual rainfall line which runs from Shark Bay south-eastwards to Southern Cross has been chosen as the northern boundary of the temperate region, since the country changes greatly in character to the south of this. From the map (Fig. 27) it will be seen that a considerable extent of hilly land outside this, but *south* of the tropic of Capricorn, is included with the tropical region, but it differs little from the other districts already considered, except that it has a rainfall of less than 10 inches.

The Murchison gold-field is situated here. A railway connects the chief centres Nannine, Cue, and Mount Magnet with the coast at Geraldton. The population of the district is some four or five thousand. Notwithstanding the low rainfall there are some sheep runs.

The South-Western or Temperate Tableland.

To the west of the 135° meridian, close settlement is confined to the south-west corner of the continent, which is the only district where good agricultural land suitable for white labour occurs. This is included in the region with which we are now dealing, which extends from the 10-inch mean annual isohyetal line to Cape Leeuwin (see Fig. 27).

The western coast is flat and low, but the Darling Escarpment rises rather abruptly from it to a height of about 800 feet, but nowhere exceeds 1,500 feet. Inland is one vast forest-covered plateau gradually attaining a general elevation of 1,000 feet. In the east the timber gives place to scrubby trees and bushes, and these in turn merge into the bare desert country.

In the south the Blackwood and Stirling Ranges are more important. The latter near Albany rises abruptly to 3,500 feet and so is a very prominent landmark. The coast line along the Great Australian Bight is very inhospitable and bounded by high cliffs, but inland from Eucla good pastoral land is reported, though permanent water is absent.

This Southern Temperate Region consists of two kinds of country. First, a triangular area of about 50,000 square miles (the same size as England), with an average annual rainfall of over 15 inches, is rich in timber and eminently suited for agriculture. Secondly, to the east is a long strip with between 10 and 15 inches of rainfall which is suitable for pastoral purposes and, as in Eastern Australia, will probably grow wheat along its wetter margins. The eastern extremity of this strip include Eyre's Peninsula, with a population of 1,000, centred round Port Lincoln. Here, though much wheat is grown, sheep farming is the chief industry.

The industrial features of the south-west district somewhat resemble those of Victoria. There is heavily timbered country near the coast, and also some coal and metals (tin in this instance). Inland the country rises considerably to dry plains beyond, which are given over to sheep. Timber is the most important product and during 1901–6 the timber cut was estimated to be worth £5,250,000, being considerably more than in any other State (pp. 194–6). Fruit-growing and agriculture do not bulk largely in Western Australia, since the districts with a suitable rainfall are still for the most part thickly clad with timber; but, as in the other States, these industries will rapidly increase in importance.

Mining, except for gold, is not of great importance in West Australia. Except for a coastal strip of late sediments (post-palaeozoic) the State consists of very old rocks (see map, Fig. 5), such as gneiss and schists, and in these metalliferous veins are to be expected. The gold-fields are discussed in Chapter XVIII. Copper (£50,000 total in 1906) occurs chiefly at Pilbarra, and *tin* at Pilbarra and Greenbushes (£158,000 total value in 1906). A small but important coalfield of mesozoic age occurs at Collie in the south-west. It is not suitable for export, being hydrous and ashy, but is used locally. The coal obtained in 1906 amounted to 150,000 tons.

The Central or Desert Tableland.

This last division of the Tableland Region is rectangular in shape, about 1,000 miles from west to east and 600 from north to south. The Lake Eyre Basin is of the same arid character, and with this addition the desert may be described approximately as occupying the rectangle between Condon and Cloncurry on the north, and Southern Cross and Broken Hill on the south.

It was naturally the last portion of Australia to be explored, for though the eastern portion was traversed by Sturt, Stuart, and others before 1863, it was not till Forrest and Giles crossed the western desert in 1874–5 that the character of the centre of Western Australia could be adequately described. At a much later date the large intervening unexplored area was crossed in a north and south direction by Carnegie (1896) and others.

Stuart endeavoured for several years to reach the Indian Ocean overland from Adelaide, but did not succeed until July, 1862. Some account of his journey will give a key to the character of the central desert. He first traversed the country to the west of Lake Torrens (in the south), which he characterized, in 1858, as a 'dreary, dreadful, dismal desert'. From Chambers' Springs, at the north of Lake Torrens, he found the country fairly covered with grass, but poor in water till the creeks (Neale's and Stevenson's) emptying into Lake Eyre, were reached. From here to the Finke River was 'a region of scrub with ironstone soil, and the country wore an appearance of endless monotony'. Thence he travelled among huge rocks and dense thickets of scrub to the foot-hills of the MacDonnell Ranges. These Stuart considered the first *real* ranges he had met since leaving the Flinders Range. Here the country seemed a fine one for pasture, but soon degenerated and, to the north, water became very scarce. At Central Mount Stuart we are told that grass was abundant and native orange trees plentiful, likewise a fine class of rose, having a strong perfume. (*Vide* Fig. 28.) North of this came a desolate expanse of spinifex and sand which finally compelled him to return.

The Hugh and Finke Rivers were now found to be dry, but he managed to reach civilization safely. In 1861 he made another attempt, and reached a good belt of grass near Newcastle Waters, considerably north of his last terminus, but beyond this 'north, east, and west the stubborn scrub interposed a barrier as of woven steel'. In 1862 the indefatigable Stuart finally succeeded in penetrating the mulga scrub, and reached fine land at the head of the Roper River, and ultimately the Indian Ocean some fifty miles east of Palmerston.

From this brief account it will be gathered that the South Australian portion of the arid region is by no means wholly barren, but consists of a series of belts of fair pastoral country, alternating with stony areas or spinifex and mulga scrubs. The best areas would seem to lie near the MacDonnell Ranges, but north of this, near Powell's Creek, and south near the west of Lake Eyre are other regions suitable for stock in good seasons.

The arid region of Western Australia is an uncompromising desert. Warburton's party (1873) crossed the northern portion, but 'fleeing as it were for their lives westward over the Sahara'. Forrest (1874) and Giles (1875–6) crossed somewhat further south, and the latter, as I have noted elsewhere, 'was able to substantiate the views of those explorers who had described the greater part of the interior of Australia as a sandy desert, unfit for settlement' (*Western Australia Year-book*).

Carnegie (1896) left the Western Australia Gold-fields to strike across the continent in a NNE. direction, in the hopes of finding gold-bearing or pastoral country in the great desert. Travelling over a long stretch of dry country, during which journey the camels were without water for 13½ days, they reached a soakage near Alexander Spring (Al. S. on Fig. 27). Beyond, a few low sandstone ranges and hills were found, and occasionally in the valleys, belts of bloodwood and a few shrubs edible by camels, but most of the country was a continuous waste of sand ridges. They reached Hall's Creek, and returned south along the South Australian border. The sand ridges in this district were so frequent that in eight hours' travelling eighty-six of them were passed over. No permanent water was found after leaving Sturt's Creek (100 miles south of Hall's Creek), and the impracticability of a direct stock route being opened between Kimberley and the North Coolgardie Fields was proved beyond question. It was, moreover, clearly shown that the desert they traversed contained no auriferous country, with the possible exception of small and isolated patches. The vegetation along the course of this journey for a distance of 700 miles consisted chiefly of spinifex. Carnegie describes it fully in his interesting book.[1] As it is characteristic of one-third of Australia, a long abstract of his account of it is given here.

Spinifex (*Triodia pungens*) grows in round isolated hummocks 1 to 3 feet high. These hummocks are a dense mass of needle-like prickles, and from them grow blades of very coarse grass to a height of sometimes 6 feet. It seems to be arranged so that it cannot be stepped over or circumvented. One must in consequence walk through it and be pricked unpleasantly. There are a few uses for this humble plant; for example, it forms a shelter and its roots make food for the kangaroo rat, from its spikes the natives in the northern districts make a very serviceable gum, it burns freely, and serves in a measure to bind the sand and protect it from being moved by the wind. In Northern Australia spinifex is in seed for three weeks, and when in this state forms a most excellent food for horses,

[1] D. W. Carnegie, *Spinifex and Sand*, 1898.

and fattens almost as quickly as oats. For the rest of the year it is useless.

Carnegie (p. 205) is of the opinion that a stock route from the MacDonnell Ranges (Northern Territory) to Coolgardie is feasible—at any rate in winter, at which season alone it is probable that the food supply would be sufficiently good. He states that the route from the Ranges to the south-west is excellent as far as the border. 'From there it would be necessary to hit off the small oases which are met with near Mount Squires, Warburton Range, Blyth Creek, and Alexander Spring (Al. S. on map, Fig. 27). From this point the route could be taken to Empress Spring, thence to Lake Wells, and thence to Lake Darlot,' about 80 miles north of the railway at Leonora.

In conclusion he says of the area traversed on his journey (see map, Fig. 27), 'We have demonstrated the uselessness of any persons (either pastoralists or miners) wasting their time and money in further investigation of that desolate region.'

Two districts in this Desert Region deserve special mention, the MacDonnell Ranges in the east and the **Western Australian Gold-fields** in the south-west. The southern gold-fields district is described from an industrial point of view in two later sections of this book (Gold and Irrigation in Western Australia). Until 1887 it was a barren desert such as has been already described, but in that year the Southern Cross field was discovered, and in 1892, partly in consequence of the report of the explorer Lindsay (1891), the Coolgardie fields were discovered. Here the only water supply at first was obtained from small 'soaks'. Later portable condensers were used to separate the salt from water derived from holes dug in the salt lakes. Before the railway was opened the Government constructed tanks along the route near granite outcrops which served as collecting-grounds after occasional rains. Each of these held about a million gallons and cost some £3,000. This precarious supply is now superseded by the wonderful waterworks described on pp. 167–8. While the gold *reefs* are worked on much the same plan as elsewhere, ordinary sluicing methods cannot be applied to the gold occurring in the surface soil. This is won by 'dry-blowing'. The simplest method is to allow the alluvial material to fall from one dish to another held below it, the wind blowing away the finer, lighter particles, and gradually concentrating the gold. For about 250 miles, from Dundas northwards to Mount Margaret (see Fig. 44), there is an almost continuous series of mines.

In 1901 about 50,000 inhabitants—or nearly one-third of the total population of the State, inhabited these interior mining-fields.

The Central Highlands.

In the centre of the Continent lies an area of elevated land—the MacDonnell Ranges—the physical characteristics of which are better known than those of many more accessible regions. This is due to the efforts of the Horn Expedition of 1894, which consisted chiefly of well-trained scientific men.[1]

Though the country was found to be extremely interesting to geologists and biologists, it must be admitted that the reports have strengthened the conviction that the centre of Australia is of very little value from an economic point of view. Professor Spencer writes that he 'hoped to find well-watered and fertile valleys. . . . In reality the ranges

[1] A full account (in four volumes) edited by Professor Spencer of Melbourne has been issued by Dulau & Co. (1896). The expedition left Oodnadatta in May and returned in August, 1894, i. e. during winter.

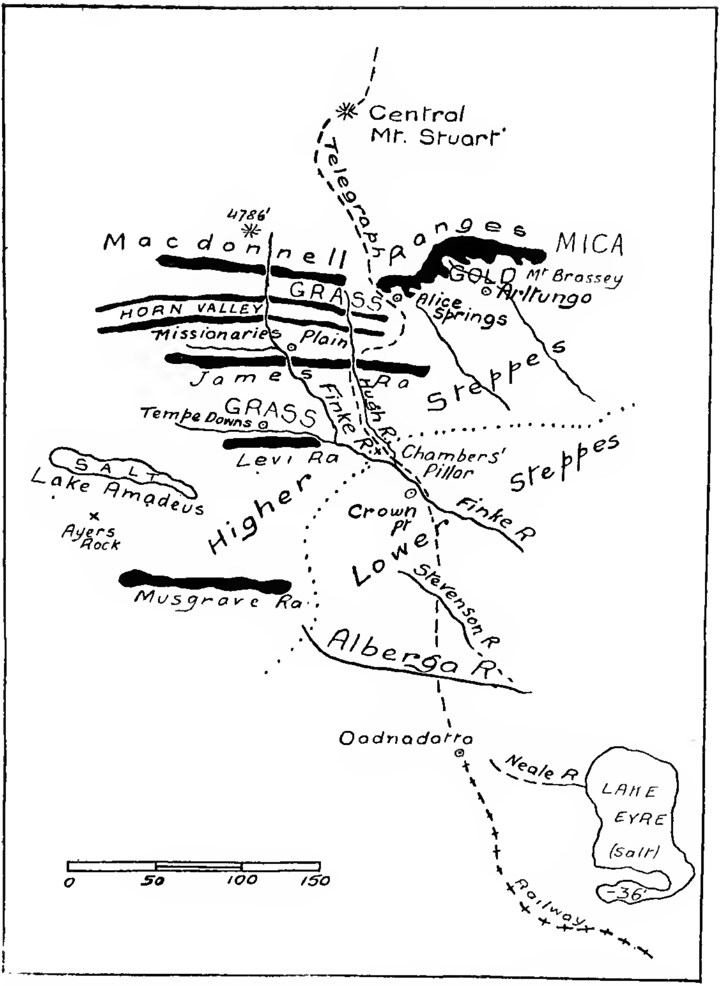


Fig. 28. The Central Highlands of Australia (based on the Report of the Horn Expedition). The east-west ridges constituting the Macdennell Ranges are shown in black.

form bare and often narrow ridges separated from one another by dry and sandy scrub-covered flats.'

The region between Lake Eyre and the Levi Ranges (see Fig. 28) consists chiefly of 'gibber' plains—which are covered with the more resistant fragments (gibbers—the 'g' is hard) of the cretaceous sandstones—and of arid loamy plains free from gibbers; both of which support a sparse saltbush flora. These are called by Professor Spencer the Lower Steppes.

As soon as the northern boundary of the cretaceous area is passed (near Chambers' Pillar) a striking difference appears in the configuration of the country. The rocks now consist of Lower Silurian sandstones and limestones which have been folded at some ancient period into a series of ridges and troughs running east and west. These corrugated strata have been subjected to a movement of elevation in quite recent geological times, and the rivers acting on the erstwhile planed surface have cut out the extraordinary series of gorges and lateral valleys which form so striking a feature of the region.

The Finke River rising north of the chief ranges has kept to the course it occupied prior to the uplift. It runs right across the steep ridges of silurian sandstone which are the relics of the more resistant beds in the originally level pre-uplift surface.[1] The tributary streams (Horn Valley, Palm Creek, &c.) have eaten their way along the softer or less stable beds parallel to the axes of the folds.

To their unusual morphological features these ranges owe the permanency of their water-supply. For it is protected from rapid evaporation in the deep gullies and gorges (some of which, though 200 feet deep, are only a few feet wide), while in the surrounding plains the rainfall evaporates almost as soon as it falls.

[1] It is thus a fine example of an 'antecedent' river.

Permanent pasture, however, is rare, and the chief cattle areas are near Alice Springs and Tempe Downs (see Fig. 28). Professor Spencer writes: 'Of late years drought and low prices have combined to render the enterprise of those who have attempted to utilize the land of the far interior a somewhat hazardous undertaking.'

To the west, as soon as the ranges are left behind, the monotonous sandhill, mulga, and spinifex country commences, and extends through Western Australia to Coolgardie. The so-called lake Amadeus (see Fig. 28) is usually a sheet of salt, about half an inch thick, and is obviously quite valueless for water-supply.

The northern portion of the MacDonnell area consists of much older rocks, such as gneisses and schists. These are probably of archaean age and allied to those covering a large part of Western Australia. Associated with them are certain 'dykes' of granite, which yield a valuable supply of the mineral *muscovite* (white mica). The chief mica mines are situated near Mount Brassey in the north-east of the Ranges, where plates of mica 6 feet across have been obtained. They are sent by camel to Oodnadatta and are exported for use in electrical works. In the same region is Arltunga, a gold-field which promised well some years ago, but it is heavily handicapped by its situation and environment.

It is to be feared that neither the cattle, mica, nor gold will lead to the prosperous settlement of Central Australia. The low rainfall (averaging only 6 inches per year over the greater part of the area) will prohibit extensive pastoral occupation, while the 200 miles of transport to the railway at Oodnadatta—and thence 600 miles to Adelaide—will prevent the exploitation of any but very rich mineral fields.

SECTION IV. A SPECIAL STUDY OF NEW SOUTH WALES

CHAPTER XII

RELATION OF ENVIRONMENT AND OCCUPATIONS IN NEW SOUTH WALES

A brief sketch of the way in which the physical conditions have governed the growth of Occupations in New South Wales will serve as an introduction to the second part of this work, which gives detailed accounts of the various industries.

From the descriptions in preceding sections it will be evident that the geological structure of a country controls its physical features and its mining industries; that climatic conditions (in Australia more particularly rainfall) as well as suitable soil, determine which regions are barren or pastoral, or agricultural.

The logical sequence is therefore—(1) Geological Features. (2) Topographical Features. (3) Climatic Conditions. (4) The Resultant Vegetation and the Consequent Industries.

Referring to the geological section drawn across New South Wales (see Fig. 29) from Broken Hill to Newcastle, it is seen that the dominant formation is a series of folded slates and sandstones, of palaeozoic age (1 and 2). These, however, are hidden from sight over half the section by two large deposits; the tertiary plains (8) in the west, and the coal measures (5) near the coast, each of which occupies a basin formed in the older sediments.

Probably at the close of the carboniferous period, a longitudinal depression was formed where the coal basin is situated, and in this were deposited the coal measures, &c. (4 and 5). Later movements led to the infilling of brackish or fresh-water gulfs by the trias sandstones (6) at Sydney and Grafton. The north-west was also receiving the enormous deposits of sand and mud which constitute the Artesian Basin. Finally, an upward movement led to a great increase in the land-surface of what is now New South Wales. The marine sands (8) on the south-west contain numerous tertiary fossils, proving that not very far back in geological time the Murray and Darling flowed independently into a huge gulf extending at this corner far into New South Wales (8, in Fig. 29).

The figures placed on the diagram indicate the order of deposition. Thus the newest tertiary strata (8) overlap the cretaceous (7) and cover the palaeozoic (1 and 2). Similarly the Sydney trias (6) overlies the coal seams (5), the coal measures (4) and the palaeozoic (2 and 3), and so on for the other areas. Three well-defined eruptive areas of economic importance are indicated. They are the granites of New England and Kosciusko, and the basalts of the Blue Mountains near Sydney (V.).

In Fig. 30 the main topographical features are represented, contours of 1,000 and 3,000 feet showing clearly the arrangement of the elevated land in the State. The influence of the geological structure is at once apparent.

The later tertiary and secondary sediments (Fig. 29, 7 and 8) are seen to constitute the western plains of New South Wales. No great earth-movements have folded these later sediments into ridges and hollows. The land slopes gradually from north-east to south-west, and is so flat that many of the rivers in flood-time cover many square miles of country, while the water of one tributary may flow into the next *across* country instead of into the main river (cf. Warrego and Paroo).

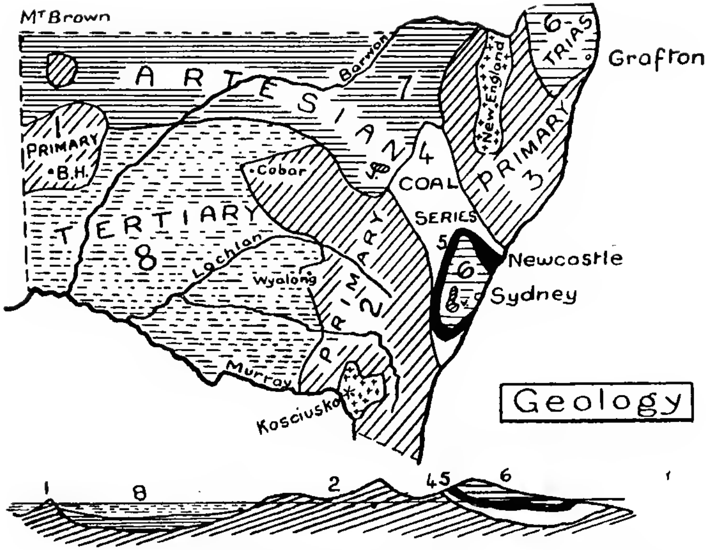


FIG. 29. Geological Conditions. 1, Cambrian; 2, Silurian; 3, Carboniferous; 4–5, Permo-carboniferous; 6, Trias; 7, Cretaceous; 8, Tertiary; V., Volcanic and (Crosses) granite.

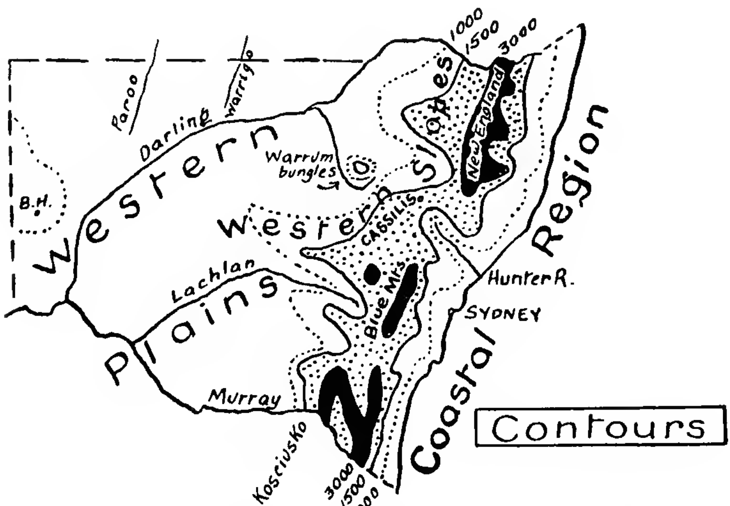


FIG. 30. The Highland Zone (dotted) separates the Littoral Zone (east) from the Western Plains.

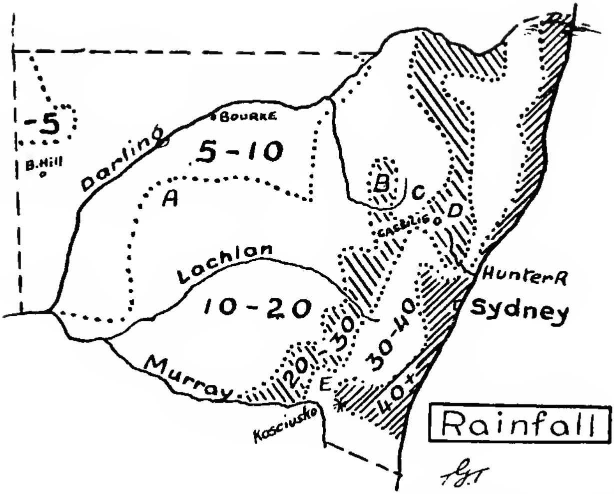


Fig. 31. Typical Rainfall in New South Wales (average for 1900). Areas between 20″ and 30″ isohyets and over 40″ are hatched. A positive (wet) loop over the Warrumbungle Mountains (b), and negative loops (c and d) are shown.

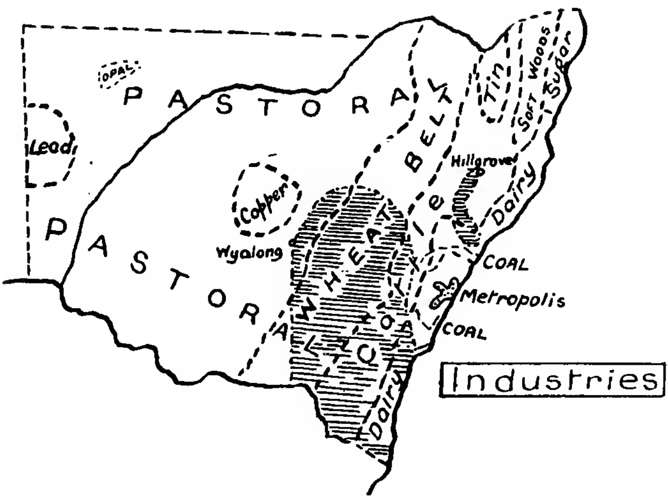


Fig. 32. The hatched area indicates the position of the Main Goldfields, interrupted by the Later Coal Basin. The radiating area around Sydney indicates the residential offshoots.

Still comparing figures 29 and 30 the 1,000 foot contour is seen to agree remarkably with the boundary between the primary and later sediments. In fact the originally rugged country between Broken Hill and the Eastern Highlands has undoubtedly been filled up and smoothed over by means of these tertiary and secondary strata. Here and there 'islands' of the older slates (2) project above the enshrouding strata, as at Mount Brown (in north-west of 29) and near Cobar, revealing the character of the bed rock.

The solid core of granite in New England and Kosciusko has determined to a large extent the position of the two main massifs in the State.

On the other hand, the Blue Mountains are largely due to a fold of late date, which was accompanied by outpouring of basic lava (basalt) the soils of which are of great economic importance (at V. on Fig. 29).

The Hunter Valley furnishes one of the best examples of the interaction of environment and life. It seems a curious train of induction which assigns the rather dry conditions of this area to the presence of the coal measures which occur there. Yet this is by no means so far-fetched an idea as it might at first appear. The Hunter River has eroded its path in the coal measures at a more rapid rate than other coastal streams which have harder rocks to work on. Thus the water-parting, a divide between the rivers of the coastal strip and those of the Central Lowlands, has here been shifted to the west. A gap in the Eastern Highlands near Cassilis has been formed (see Fig. 30). The rainfall of the low-lying Hunter Valley is comparatively slight (see Fig. 31), and the flora of the drier west has migrated over the divide and is found in the Upper Hunter Valley, and nowhere else to the *east of the Main Divide*.[1]

[1] This interesting question of the Correlation of Contour and

Undoubtedly the question of rainfall is of the first importance in a country devoted to agriculture and pastoral pursuits. In Fig. 31 the lines of equal rainfall (isohyets) are plotted for the year 1900. The curves closely resemble the average ones for the last ten years, but some points are emphasized in this diagram. It will be seen that the rain zones are parallel to the coast and to the belt of highlands. Such a distribution was to be expected.

The curves, however, are by no means regular, and any apparent abnormalities can be readily explained by reference to the topographical diagram (Fig. 30). The bulge A projecting from the wet regions is due to the low ranges around Cobar, for a comparatively small elevation is sufficient to raise moist winds into somewhat cooler regions, thus causing a slightly heavier rainfall than in the lower adjoining lands. At B a very well-developed bulge of a similar nature is due to the isolated volcanic mountains at the head of the Castlereagh River. At C and D the huge Cassilis gap causes a bulge of the 30-inch isohyet from the dry region almost to the coast, with the effect on the vegetation of the Upper Hunter Valley just noted. Lastly, the elevation of Kosciusko (about 7,300 feet), and the surrounding summits, is accountable for the westward bulge shown at E.

We may now consider the effect of these conditions on the commercial and industrial problems of the State.[1]

Fig. 32 shows the distribution of different phases of industrial development. Neglecting the mineral industry

Climate is discussed in a paper by the author, v. *Proceedings Linnean Society*, New South Wales, Part III, 1906.

[1] The following paragraphs will be found to repeat to some extent information already given in Chapters VII and VIII, but this is necessary to give a comprehensive picture of the interrelations of the factors which control industrial life in New South Wales.

for the moment, New South Wales may be divided into three zones, each with its characteristic occupations. These correspond roughly to the belts beyond or between the isohyets of 20 and 40 inches, and may be called the Coastal Belt, the Highlands (above 1,500 in Fig. 30), and the Plains.

The Coastal Belt is a strip about 20 miles wide, but extends further inland along the lower courses of such rivers as the Clarence and Hunter. The Hunter plains run inland for nearly 100 miles. The heavy rainfall on the northern part of the coast, combined with the warm temperature, has led to the profitable cultivation of sugar-cane. With this exception, the most important occupation of the coastal belt is dairy farming, which was first started in the south and rapidly displaced other occupations all along it. Mixed crops are also grown, and stock is raised in farms which produce butter, milk, and cheese.

Around the capital other industries have grown up, partly owing to different geological conditions. A somewhat sterile series of triassic sandstones has prevented agriculture from forming the staple industry. The shales around Parramatta are devoted to fruit culture. The rugged beauty of the sandstone gorges in the Blue Mountains has led to the growth of numerous tourist and residential towns. Vegetation flourishes luxuriantly only where the outflows of basalt have enriched the triassic soil, and these 'red-soil' hills are now almost wholly cleared of trees and converted into farm lands.

Encircling this area of sterile land, and also lying beneath it, is a black area (see Fig. 29) of potential wealth hardly rivalled in the southern hemisphere. In addition to the coal, which lies 3,000 feet below her streets, Sydney is surrounded at a radius of 70 miles by outcrops of splendid steam coal, which are among the most valuable natural assets of the State.

On the rougher slopes of the Highland Belt both cattle and sheep are bred. Towards the south the climate is too rigorous for the merino sheep, though crossbred sheep do better. Here, where the rainfall is greatest, most cattle are raised.

In the north of the Highland Belt are the tin-bearing granites of Inverell and Tingha. The eruptive rocks also contain gems and minerals of lesser value, such as topaz and tourmaline, which usually accompany tin deposits. This is important, because the Kosciusko granites, which are practically devoid of such mineral constituents, are also much less rich in tin.

The western slopes of the Highlands form the chief wheat belt of the State. Here the necessary warmth and moisture are found, along with a fairly rich soil. The chief gold mines of the State are in the palaeozoic rocks of this region.

Ore deposits, usually due to the cooling of thermal waters carrying mineral salts in solution, more readily occur in the older rocks than in the newer sediments. The latter have not been subjected to such violent or such long continued crystal movements and chemical action. In New South Wales the later sediments are unusually free from complex folding, while the western plains are composed of newer sediments almost as level as when they were deposited in the old tertiary gulf or lake. It would be absurd to look for valuable gold, copper, or lead *veins* in these geologically recent rocks. *Alluvial* gold and tin occur in tertiary deposits, but are always associated with the palaeozoic rocks from which they have been derived.

The third belt (the Western Plains) coincides approximately with the level tertiary and secondary deposits. In the north there is the Artesian Basin of New South Wales. The whole country is devoted to breeding sheep for wool, the numbers of sheep per acre increasing from west to east with the rainfall. The low-lying land near the rivers especially in the Riverina district, will soon be cut up into irrigation farms, for which there is a great future.

The newer rocks, however, contain one valuable mineral, the precious opal. This is found sporadically but fairly abundantly in the north-west of the Artesian Basin. In this district is the Mount Brown goldfield, an island or inlier of older rock which does not happen to be covered by the later secondary strata.

Lastly, on the western edge of the State is an area of very old rocks, possibly Cambrian in age, which contains the silver-lead of Broken Hill (see pp. 173–6). Here, in spite of a rainfall of little more than 5 inches per annum, and costly transport through another State, the third largest town of New South Wales has arisen. This is a striking example of an economic product proving sufficiently valuable to neutralize disadvantageous elements of a poor environment.

PART II

ECONOMIC ASPECTS

SECTION I. STOCKRAISING

CHAPTER XIII

THE WOOL INDUSTRY

THIS the staple industry of Australia is confined within fairly well-defined limits. The controlling factors are almost wholly climatic and will be best understood by a reference to Fig. 33.

As a general statement it may be laid down that the sheep-breeding industry is most profitably carried on where there is between 10 and 20 inches of rainfall in the year. With a low rainfall the herbage is too scanty, though the indigenous 'saltbush' will grow where grass has no chance. On the other hand the saltbush is not readily renewed, and requires several seasons' rest when it has been severely cropped. Where the annual rainfall exceeds 30 inches the sheep need greater care as they are liable to foot-rot and other diseases.

Temperature is another factor determining the distribution of sheep, which, as they possess a protective fleece, are essentially animals of the temperate zone. The northern limit of sheep-breeding appears to be defined by an average temperature of 75° F.

Fig. 33 is a generalized diagram showing the effect of combining the two factors of rainfall and temperature. It is at once apparent that almost the whole of New South

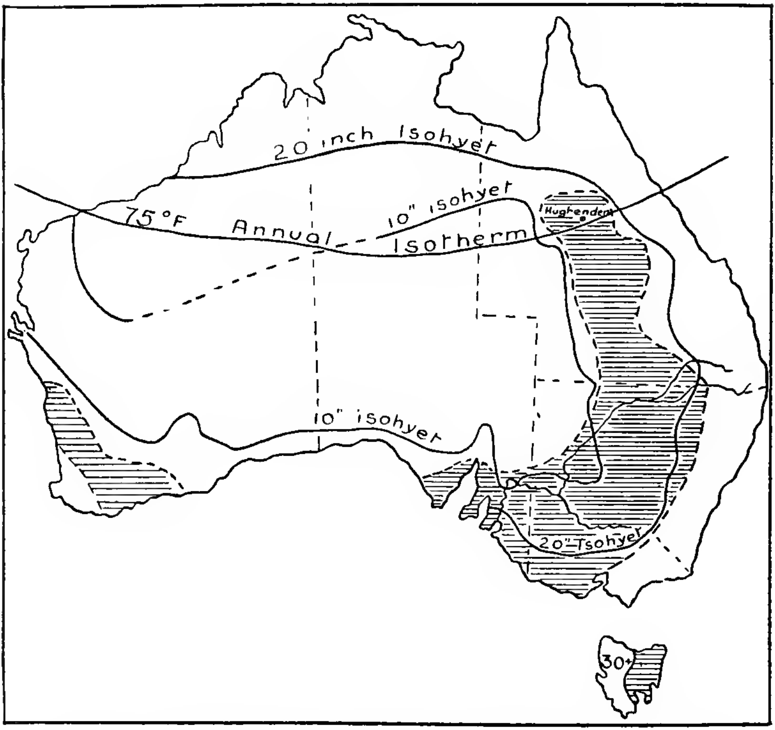


FIG. 33. Correlation of Sheep and Climate. The main sheep areas defined roughly between the 10″ and 20″ isohyets and the 75° isotherm.

Wales and Victoria lies in the sheep belt, while South Australia, Western Australia, and Queensland have only their southern portions included in this suitable zone. The number of sheep and the percentage in each State of the

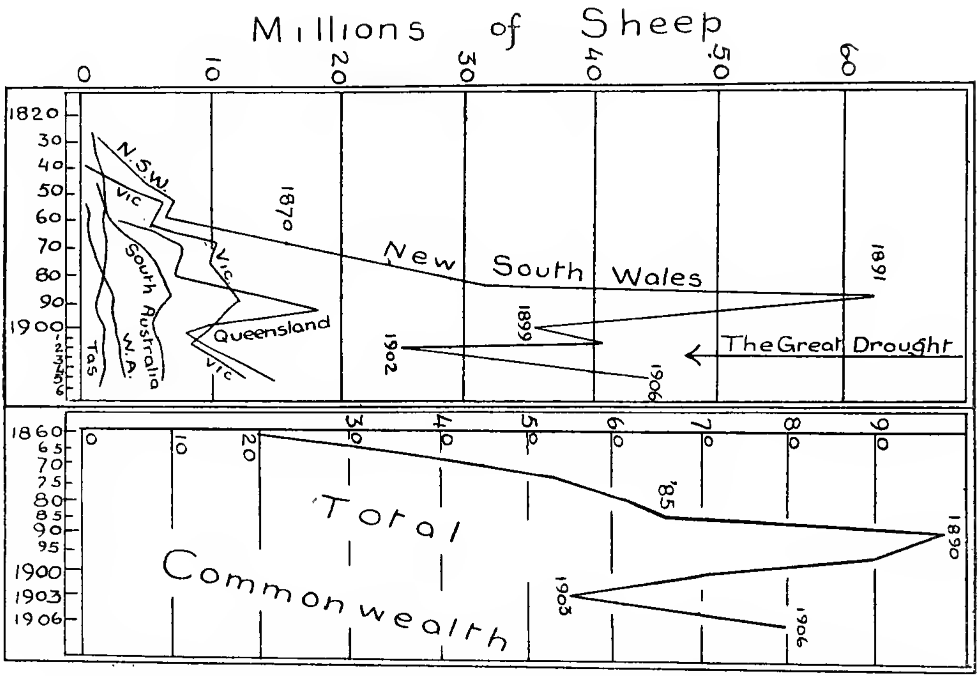


FIG. 34. Number of Sheep in Australia, 1820-1906, showing the Effect of the Great Drought.

Commonwealth and of New Zealand were as follows in 1908:—

New South Wales . . .	43·3 millions	49·8 %
Queensland	18·3 ,,	21·0 %
Victoria	12·6 ,,	14·5 %
South Australia . . .	7·0 ,,	8·0 %
Western Australia . . .	4·1 ,,	4·7 %
Tasmania	1·7 ,,	2·0 %
	87·0	100
New Zealand (1909) . .	22·4	

In Fig. 34 the variation in the number of sheep for each State for seven decades is charted. New South Wales has,

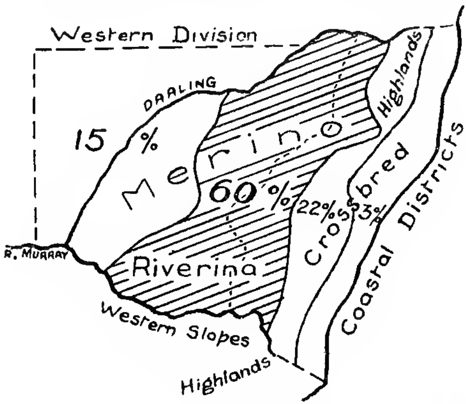


FIG. 35. Distribution of Sheep in New South Wales.

therefore, as many sheep as all the other Australian States added together, so it is legitimate and helpful to consider in some detail the wool industry of New South Wales as typical of the whole.

The sheep in New South Wales number some 40,000,000. This is a decrease of 20,000,000 from the number in 1891, when the runs were undoubtedly overstocked. The effect of a series of bad seasons on the pastoral industry is very strikingly shown by the drop (in Fig. 34) during 1901–2 when, it has been stated, the drought caused a loss of £127,000,000 to Australia. Under present conditions (1907) New South Wales is comfortably stocked, but there is little doubt that with improvements in water conservation, and in the growth of food crops, the number of sheep will be enormously increased. At the average rate of increase since the Great Drought, the sheep would be doubled in four years.

The distribution of sheep in the State is shown by Fig. 35.[1] Using the topographical divisions already adopted—the Coastal Belt, the Highlands, Western Slopes, and the Western Plains—the following table shows the quantity and quality of the sheep pastured thereon :—

Belts.	*No. of sheep in* 1904.	*% of whole.*	*Breed of sheep.*	*Remarks.*
Coastal	1,037,011	3	Coarse wool sheep, such as Romney Marsh	Large hardy animals more suitable for mutton.
Highlands	7,783,680	23	Merino, coarse wool (Lincolns, Leicesters, &c.), with Merino cross breeds	A Lincoln carcase (dressed) weighs 60 lb. as opposed to 46 lb. for a Merino.
Western slope and Riverina	20,581,852	60	Best breeds of Merino	Best wool country in the World.
Western Plains	5,124,351	14	Somewhat poorer classes of Merino	Saltbush country, hot but healthy.

The greatest number of sheep are fine-woolled Merinos, which thrive better in New South Wales than anywhere

[1] Based on tables in the *Official Year Book of New South Wales*, 1904–5, where a clear account of the pastoral industry may be consulted.

else. The physique of the sheep, however, deteriorates unless vigorous new stock is introduced. This is largely obtained from Tasmania, which has a cooler and more bracing climate. Many coarse-wool sheep, and cross breeds between them and the Merino, are found in the coastal regions. The proportions are given as follows in the *Official Year Book*:—

Fine wool	Merino	31,840,000
Coarse wool	Cross-bred, chiefly Lincoln-Merino	1,800,000
	Lincoln	250,000
	Leicester	170,000
	Romney Marsh, Shropshire, and South-Down	60,000
		34,120,000

In recent years many changes have arisen in the sheep industry. Through careful breeding the fleeces have improved in quality almost beyond belief. The fleeces of the first flock were only about 3½ lb. in weight, while a modern prize fleece weighs 30 or 40 lb. The general average for the whole State has risen to 8 lb.

The conditions of ownership have altered materially. The large holdings (' stations ') are being split up, although there is still one Riverina station with 150,000 sheep. Many of the small farmers practise mixed farming—rearing sheep, especially cross-bred, as well as raising agricultural crops. As this practice is proving very profitable it will doubtless be extended. The old method of shepherding sheep is gradually falling into disuse, and fencing-in large paddocks has proved more economical. The almost universal use of machine shears has lessened the labour of shearing.

One drawback of the pastoral industry has, however, changed for the worse of late years—the rabbit plague. Residents of other lands can have little conception of the damage done by these rodents. In the far west the rabbits eat all the grass off, and worse still, nibble the bark of the edible shrubs and saltbush (*Chenopodium*, *Atriplex*, &c.). The black and withered shrubs look as if a bush fire had swept over them. In these regions the writer has seen dead rabbits hanging in forked branches, into which they have slipped, having actually climbed small trees to get at the green leaves.

Labour conditions have been affected by the abundance of rabbits. As winter approaches many regular station hands leave steady work to go rabbiting for the Sydney market. As much as £3 a week can be earned in the pleasant out-of-door occupation of trapping rabbits. Wealthy station owners during this season may be personally compelled to drive round the poison cart (to drop baits of phosphorized meal for the rabbits) in place of a defaulting hand. The rabbits seem to be gradually marching east and north, and during the last ten years have spread over the divide towards Goulburn. The only means of defence, one which needs constant attention, is to put up rabbit-proof fencing, of which 44,000 miles, costing nearly £2,500,000, have been erected in New South Wales.

Shearing takes place chiefly during August and September, but is earlier in the north and later in colder portions of the State. The wool bales, each weighing about 350 lb., are sent in the greasy state to Sydney. Here a considerable portion of the wool is 'scoured', i.e. washed in soapy water. The 'yolk', a potash fat natural in wool, is thus removed and the wool rendered bright and clean. The valuable by-product is not utilized at present, but lubricating grease, and possibly potash-salts, will be extracted in the future, as they now are in France. The scoured wool is worth nearly double that of the greasy wool (25*d.*/15*d.* being the ratio). Most wool is now sold in

Sydney in the greasy state. During 1905–6 only 11 per cent. of the Australasian wool was scoured.

As will appear from the following table, the greater proportion of Sydney wool (77 per cent. in 1906–7) was sold to buyers on the continent of Europe. This is a remarkable reversal of conditions, since not many years ago by far the larger part of the wool went to England, whence no doubt much was re-exported. It is, however, more convenient, to send wool by the Suez route to Germany and France through Genoa and Marseilles, than to carry it first to London. Continental buyers, who import unscoured wool, favour Sydney; Victoria and New Zealand send a much greater proportion of their wool to England.

Distribution of Australian Wool, 1906–7 (in Bales).

	Sydney Sales.	*Melbourne.*	*All Australia.*
Home Trade	75,000	153,000	306,000
Continent	513,000	190,000	783,000
Local manufacturers	42,000	12,500	66,000
United States	21,000	75,000	98,000
Japan and India	14,000	13,500	32,000

From Goldsbrough, Mort & Co.'s Report for 1906.

The bales exported from the various States during 1905–6 are as follows (based on Customs returns):—

New South Wales	816,000 bales
Victoria	267,000 ,,
Queensland	176,000 ,,
South Australia	119,000 ,,
West Australia	42,500 ,,
Tasmania	33,000 ,,
New Zealand	415,000 ,,
	1,868,500 for Australasia.

Although most of the sheep in Australia are bred for wool and are not profitably adapted for food, yet about 10 per cent. of them are used as mutton. Since the establishment of freezing works there is less risk of over-stocking. Many breeders, especially in the Highlands, are breeding large cross-bred sheep for food supply. An interesting table in the *Official Year Book* shows how the increase of sheep in New South Wales from 1903 to 1904 was obtained.

Sheep at end of 1903		28,500,000
Lambs of 1904		10,500,000
Sheep imported		500,000
Deduct		39,500,000
Sheep exported	500,000	
Killed for food on 'stations'	1,000,000	
Killed for food for Australia	1,500,000	
Tinned or frozen	630,000	
Loss by casualties, &c.	1,250,000	
		5,000,000
Sheep at end of 1904		34,500,000
	Increase	5,000,000

In connexion with this most important industry in Australia, a short description of a big shearing may not be out of place. For further details on this and allied topics the reader is referred to Professor Wallace's book, *Rural Economy and Agriculture of Australia and New Zealand* (published in 1891 by Sampson Low & Co.).

The work of shearing is done within a large building—the wool-shed—of which a typical ground plan is given in Fig. 36. The sheep are driven into a drying-shed which holds enough sheep for one day. It is important that the wool should be quite dry when shorn. Otherwise it ferments. (This fermentation is used in fell-mongering to loosen the wool from the hides.) A portion of the sheep are from time to time driven into the 'yard-up' and so into the small pens. Along the walls is the chief feature of the shed, the 'shearing-board', where the men stand with their shears, machine or hand worked. After being shorn the sheep passes into the long narrow pen where it can be inspected and turned loose.

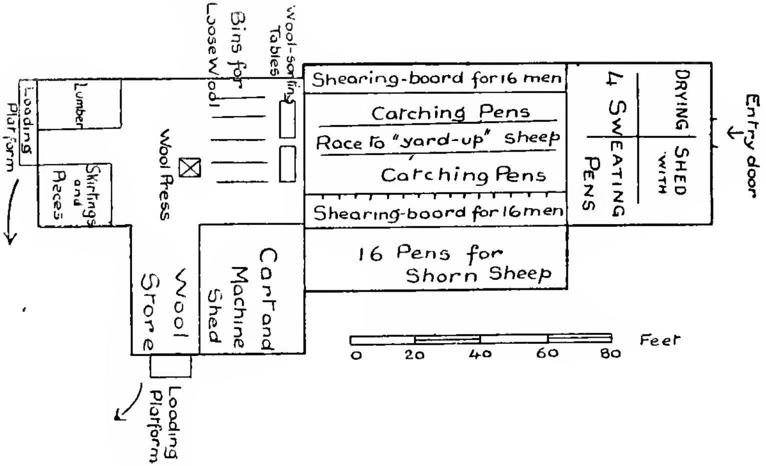


Fig. 36. Ground Plan of Wool-shed.

The wool is sorted roughly and packed in bales of about 350 lb. each, either by a screw press or by hydraulic power. They are bound with hoop iron and carried to the ports for shipment to Europe or elsewhere.

CHAPTER XIV

CATTLE IN AUSTRALIA

THIS industry is not nearly so important as the sheep industry. Although in many of the cooler regions where sheep are reared, cattle also graze, yet the latter are found to thrive on wetter country than sheep. So as a rule the wetter districts in the east and north are the strongholds of cattle, which have been to a certain extent replaced by sheep in many of the more southern localities. In the annexed sketch-map (Fig. 37), showing the distribution of cattle in Queensland, which is the chief State for that branch of the pastoral industry, it will be seen that they are found most thickly along a belt which coincides fairly closely with the belt which has a mean annual rainfall of over 20 inches, while sheep thrive better in somewhat drier and more central districts.

'On most cattle stations breeding and fattening are combined,[1] the heifers when weaned being drafted into a heifer paddock, to ensure their not breeding till of mature age; and the three-year-old steers being run in the bullock paddock, where they are kept till ripe for the butcher or the meat-preserving works. But on some stations where the creek flats and rich bottoms are of superior quality it is found more profitable to fatten only, store bullocks being bought annually during winter and spring, and turned off as "fats" as they mature during the summer. There are also a good many stock-owners who are fortunate enough to have freeholds of from 10 to 30,000 acres of rich land near a market, which they use for fattening, and which

[1] See *Queensland Year Book*, 1907, p. 79.

they supply with "stores" from their own breeding-stations leased to them by the Crown. Good fat bullocks on the coast country average from 760 to 800 lb. The cattle trucked from the west far exceed these weights, and the pens of western bullocks can be easily distinguished in the sale yards, great mountains of flesh scaling over 1,000 lb. when dressed, whose huge bulk, though somewhat wasted by travel, fairly dwarfs their coast-fed relatives. Such cattle have probably travelled hundreds of miles from their distant pastures to the railway trucks, but the quality of western grasses permits of cattle carrying condition for long distances without serious loss of weight.'

Turning to the other States where cattle also bulk largely as a source of wealth, we get the following comparative figures from the *Commonwealth Year Book*:—

		1905.		1906.
Queensland		2,963,695	head	3,413,919
New South Wales		2,337,973	,,	2,549,944
Victoria		1,737,690	,,	1,804,323
South Australia	South	300,721	,,	680,095
	North	346,901	,,	
West Australia		631,825	,,	690,011
Tasmania		206,211	,,	211,117
	Total	8,525,016		9,349,409

Since the disastrous drought of 1902–3, the figures have been slowly increasing, but the three leading States have not altered much relatively. There seems little doubt, however, that in the near future Queensland and Northern Territory will become the chief cattle strongholds.

Two branches of cattle industry are receiving much attention in Australia at present. One is the frozen meat and meat-preserving trade, and the other **dairying.** A few words on the latter will not be out of place. In New South Wales in 1905 the value of the export butter trade was about £600,000. 'It is only during the last fourteen

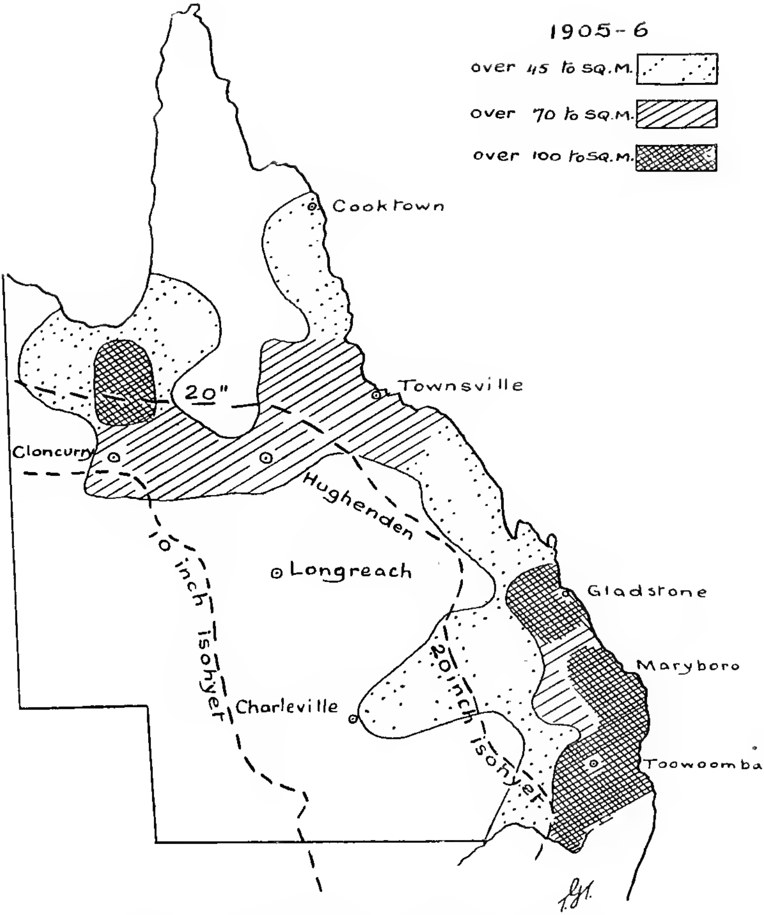


FIG. 37. The Distribution of Cattle in Queensland.

years that Australian butter has seriously influenced the London market, for though small consignments had been sent previously to London, the huge import into that city from Denmark and Sweden practically controlled the price of the Australian article. The position is now, however, changed, for in 1905 Australian butter represented over 18 per cent. of the total imports, nearly one-third of all the butter imported into London during the winter months being of Australian origin.'[1]

The cattle bred for dairy purposes need milder climatic conditions than those reared for beef only, so that dairy-farming is mainly confined to the coastal districts. In New South Wales (see Fig. 38) the centre of the industry has migrated from the south coast to the north coast, where land is cheaper and the rainfall in general heavier than in the original centre of dairying in the Illawarra district. Mr. O'Callaghan (chief dairy expert in New South Wales) writes as follows:—

'Along the coast it is quite safe to carry on dairying alone. Except in very extraordinary years the rainfall will be sufficient to make the success of the industry a certainty; but where a farmer moves inland to where the rainfall varies from say 27 to 30 inches per year, he has to think a bit more. In such districts the combination of dairying with wheat growing or mutton-raising, or both, might be entered into . . . . . . The breeding of cross-bred lambs for export goes very well with dairying, the sheep being confined to the higher lands and drier pastures, while the milch cows are allowed the run of the most succulent foods and grasses. Land similar to what in this State can be bought for £5 per acre is let in England and Ireland for about a £1 a year rent, and yet butter is

[1] *The Official Year Book of New South Wales for* 1905-6, p. 409.

almost as dear, or as valuable to the farmer in New South Wales as it is in Ireland.'

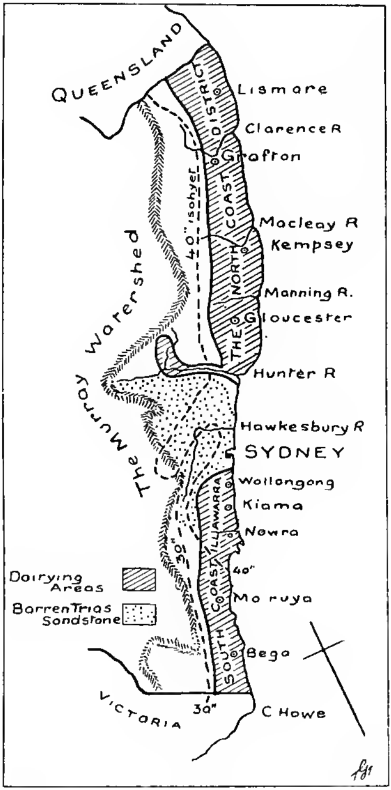


FIG. 38. Dairying Regions of New South Wales.

Referring to Fig. 38, it will be seen that the two dairying districts are separated by a well-defined central area. This, as already pointed out, is the comparatively barren district where the coal measures have been capped by the triassic sandstones, which weather to a sandy soil lacking in plant food. It will be seen that the western boundary of the dairy country coincides very closely with the 40″ isohyet; and that the whole area is fairly well watered by short rivers rising in the highlands, which here approach within about 100 miles of the coast.

Seventy-five per cent. of milch cows in New South Wales are in the coastal districts. The distribution in the States in 1905–6 was as follows:—

Coastal (*vide* Fig. 38)	North Coast	117,811
	Hunter and Manning	80,762
	Triassic area round Sydney	21,475
	South Coast	103,300
Highlands	See Fig. 30	62,460
Western slope		38,367
Western plains		18,775
	Total	442,950

The following figures showing the breeds of cattle in New South Wales may be taken as typical of the whole continent (1905):—

	Pure-bred.	*Crossed with shorthorn.*
Shorthorn (Durham)	571,337	
Hereford	171,252	295,000
Devon	63,688	160,000
Ayrshire	34,645	91,000
Jersey	24,913	24,000
Totals	865,835	570,000

Other breeds recognizable	100,000 approx.
Unrecognizable	502,962
In towns (unclassified)	297,273
Total	2,300,000 approx.

In the far north of the continent, from Melville Island to the Gulf Country, is the habitat of the wild buffalo. This animal was introduced from the Malay Archipelago, when government settlements were founded in the northern territories in 1827. When the settlements were abandoned the cattle ran wild and now number many thousands. Melville Island is the stronghold of a powerful tribe of Australian aborigines, who allow no white men on their island, with the exception of a small party of buffalo-hunters. This animal must not be confused with the bison (the so-called 'buffalo') which has been practically exterminated in North America. It is characterized by the fact that the horns are flattened and angulated, not rounded, as in oxen and bison, and are placed below the vertex of the skull. Some Australian bulls are stated to have reached a ton weight, and their hides, 'reaching nearly an inch in thickness,' are yielding satisfactory incomes to hunters in the far North.

CHAPTER XV

ARTESIAN WATER

THIS subject may well be considered in conjunction with that of the pastoral industry, since the two are so closely connected in practice. Whatever may be the difference of opinion as to the value of artesian water in agriculture, there is absolutely none as to the vital assistance it offers the harassed stock-owner in times of drought, and equally none as to its merits in keeping open the great stock routes of Central Queensland and South Australia.

A large portion of Central Australia is probably beyond the reach of reclamation. In common with most desert lands, the soil is rich in plant foods, but without moisture these possess no value. A very occasional moderately wet year works a wonderful change and has led to temporary settlement. In the southern part of this region is a striking instance of misplaced energy. When the writer was travelling through the Lake Torrens district in the summer of 1906–7, near Willochra, the train was enveloped in a dense choking sand-storm, in which one could not see across the car. This sand-storm is periodic, and is due to the ground having once been ploughed and harrowed for a wheat crop, so that the shifting surface is now displaced by every wind. The saltbush formerly formed an excellent food for sheep, but, as mentioned in Chapter XIII, p. 133, the rabbit plague has devastated the country, so that forlorn, broken-down fences alone testify that the country was once occupied. Till one gets to the far northern portion, mining is practically the only industry attracting any attention.

Practically the only mitigating influence in this arid region is the presence of artesian water in the eastern portion.

In Fig. 39 the very large extent of the Australian artesian basin is apparent. It indeed includes 576,000 square

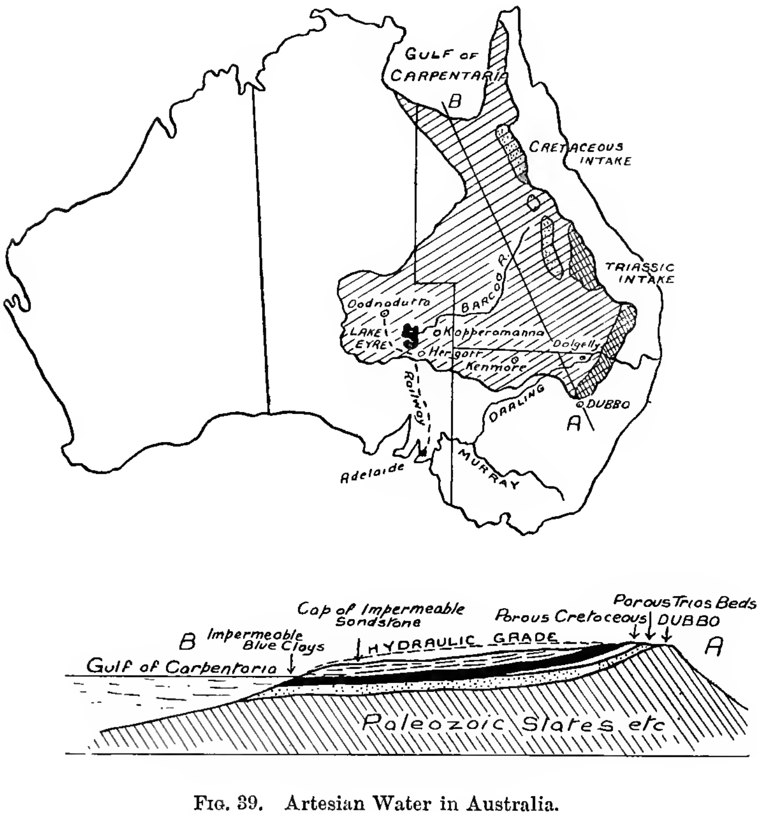


FIG. 39. Artesian Water in Australia.

miles, comprising more than half of Queensland and important slices of territory in New South Wales and South Australia.

The various governments concerned have spent large sums in sinking bores, usually by diamond drill. In New South Wales there are sixty-seven government bores giving 30,000,000 gallons per day, or approximately 450,000 each. At Dolgelly, in the south-east of the basin, a bore was sunk 4,086 feet and gave 682,000 gallons per day. At Kenmare in New South Wales (see Fig. 39) over 2,000,000 gallons are obtained. In addition, there are about 250 private bores in the State, with a total flow of 150,000,000 gallons per day.

In Queensland over 225 *miles* of boring have been put down. The south-western portion has not been exploited yet, but in the more populous districts there are nearly 600 flowing bores and 168 sub-artesian, where the water does not flow to the surface, but is pumped up. The average depth per bore is 1,221 feet.

In South Australia, as will be seen from the map (Fig. 39), the artesian basin is far distant from settled areas. The railway to Oodnadatta (whence trains run fortnightly) reaches the artesian basin near Hergott Springs. Here the great Queensland stock route commences, and during the period August to December, 1901, 14,000 cattle and nearly as many sheep passed along this route. This has been made possible by means of the government bores and tanks. There are five bores connecting Hergott with Cooper's Creek (Barcoo R.) at Kopperamanna.[1]

The cost of boring varies with the location and rock. For each foot down to 2,000 feet, charges range from fourteen to forty-two shillings. At 4,000 feet the range is from twenty-eight to sixty-five shillings. The scales for

[1] A vivid description of this portion of Australia Infelix is given in Gregory's *Dead Heart of Australia*. Here also he discusses the origin of the artesian water, advancing the plutonic theory, which is briefly mentioned at the end of this chapter.

watering stock are usually one shilling per hundred for sheep, and one penny each for horses, cattle, and camels.

Enough has been said to demonstrate the value of artesian bores to travelling stock. As regards their use in agriculture opinions differ. It has been stated that artesian water rapidly saturates agricultural land with salts, chiefly sodium carbonate. The following analysis (by Mr. J. C. Mingaye) shows the total grains of solid matter in a gallon of Pera water (a bore near Bourke, New South Wales).

Sodium Carbonate . . .	33·12
Potassium Carbonate . .	1·20
Sodium Chloride . . .	7·69
Silica	1·06
Lime Carbonate . .	0·85
Traces of other salts . .	1·12
Total solids .	45·04 grains

Experiments with this water have yielded very good results in the case of fruits, lucerne, &c., and the above analysis would seem to be an average type of the artesian supply. There can be little doubt, however, that water conservation and supply for irrigation purposes are capable of yielding profits on a much greater scale, and probably in the future most attention will be given to this method of making the desert bloom.

The present arid conditions in Central Australia and the structure of the artesian basin can be most clearly explained by a brief review of the geological history of this area.

Around the shallow salt lakes of South Australia (Fig. 26) is a happy hunting-ground for geologists. Here occur skeletons of extinct animals of comparatively recent date, such as the giant emu, giant kangaroo, alligator, tortoise, and giant wombat. The latter (*Diprotodon*), some 16 feet long, was a herbivorous animal, flourishing only in well-grassed and fairly well-watered country. All of these have become extinct, and only where they have been engulfed in mud are their bones preserved to tell of a time when Central Australia was a smiling, fertile region.

The central portion of Australia has been subjected to many ups and downs during the tertiary period (see p. 207). About the time when huge reptiles dominated the animal kingdom (jurassic and cretaceous periods, see footnote, p. 27), a large gulf undoubtedly extended from the Gulf of Carpentaria to Lake Eyre (see Fig. 40). This covered much

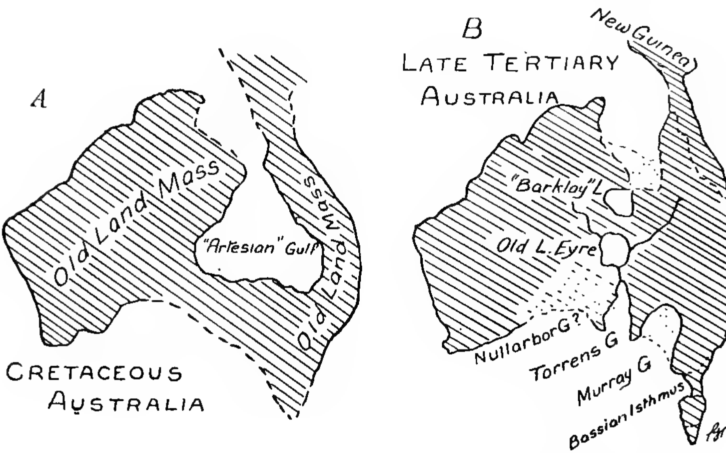


FIG. 40. Australia in Cretaceous and Late Tertiary Times.

the same ground as the artesian basin, and in it were deposited thick beds of sand which ultimately became a permeable sandstone. Over these were laid down clays of an impermeable nature (blue clays, &c.) and other strata of less interest.

Later, earth movements elevated this area, and the action of wind and weather eroded the eastern edge of the basin, exposing the underlying porous sandstone (see section B A, Fig. 39).

The more recent history of the artesian basin is of great interest and shows how the climate gradually became more and more arid, until its present condition was attained.

Professor Gregory is of the opinion (see *The Dead Heart of Australia*) that *after* the deposition of the cretaceous sediments in the artesian gulf and their elevation into land, a series of earthquakes, resulting in parallel fractures or faults, led to the formation of the South Australian gulfs, and probably of Lake Torrens (see Fig. 26), so that there may never have been a continuous gulf across Australia from north to south. There was then a much greater rainfall in Central Australia, probably due to the larger water surface. Lake Eyre had an outlet and formed a magnificent sheet of fresh water which extended over three times the present area, and was fed by large rivers. At this period flourished the gigantic animals mentioned previously. Unfortunately this happy environment has not lasted. It seems probable that this lowland zone from gulf to gulf (see Fig. 40 *B*) has been subjected to a movement of elevation, leading to land extensions, giving Australia its more familiar outline, and causing the drying of Lake Eyre, and the exposure of the tertiary deposits of the Barclay Tableland and elsewhere. At the same time, there was a movement of subsidence along the eastern coast, accompanied by earthquake slips in Bass Straits, and possibly in Torres Straits, leading to the separation of Tasmania and New Guinea. Along the rest of the coast a more gradual subsidence led to the formation of splendid harbours from drowned river valleys (e.g. Sydney), and indirectly to the formation of the Great Barrier Reef [1] (see pp. 205–6).

[1] The aspect of environment dealing with this 'rocking' of coast and lowland is developed in a paper read before the Australian Association for the Advancement of Science, Adelaide (Hedley and Taylor, *The Reefs of the Great Barrier*, 1907).

The rain falling on the upturned porous beds (which are chiefly trias in New South Wales and cretaceous in North Queensland) is rapidly absorbed and flows underground towards the lower portion of the basin, which probably occurs in the north. In fact, it seems likely that there is a large leakage into the Gulf of Carpentaria. How then does the artesian water rise in the bores to a height considerably above sea level in the gulf? Professor David has shown[1] that the frictional resistance to continued flow, which must be very great, is equivalent to a barrier in the sense that it induces a hydraulic pressure. Hence the height to which the water rises above ground gradually diminishes as the outlet of the basin is approached (see line of hydraulic grade in the section, Fig. 39).

In conclusion, it may be stated that the theory of the *atmospheric* origin of the artesian water has been questioned by Professor Gregory. He suggests that it is mainly derived from water which is included in minute cavities in almost all granites and other similar rocks. He instances the steam escaping from volcanoes and the presence of ores, deposited by thermal water, as evidence of large quantities of underground water. The diminution of some bores, pointing to their possible exhaustion, and the chemical contents of the waters lend considerable support to the *plutonic* or underground origin theory of artesian water. The balance of opinion is,[2] however, in favour of the artesian water being directly derived from rain falling on to porous outcrop, and thence supplying the water-bearing strata many hundred feet below the arid surface.

[1] For a lucid account of the artesian basin, see Pittman's *Mineral Resources of New South Wales*, p. 457.

[2] Strong arguments against Professor Gregory's theory of the plutonic origin of artesian water were set forth by Mr. Pittman in a paper before the Royal Society of New South Wales.

SECTION II. AGRICULTURE

CHAPTER XVI

WHEAT IN AUSTRALIA

ALMOST all Australian wheat is grown in the States of Victoria, New South Wales, and South Australia. For 1905–6 the figures were :—

	Acres.	*Bushels.*
Victoria	2,070,517	23,417,670
New South Wales . .	1,939,447	20,737,200
South Australia . . .	1,757,036	20,143,798
Western Australia .	195,071	2,308,305
Queensland	119,356	1,137,321
Tasmania . . .	41,319	776,478

A glance at the sketch-map of the wheat areas will show how intimately they are related to the rain belts (see Fig. 41).

New South Wales. The western limit of profitable wheat-growing in New South Wales practically coincides with the mean annual rainfall of 23 inches. A little more rain is needed in the *hotter* northern portion, while in the south, on the Murray, 20 inches is sufficient. A great deal depends on the month in which the scattered Australian rainfall occurs. September and October, the period during which the grain fills, are the most critical months.

The year 1897 may be said to mark the beginning of the present era of wheat-growing in New South Wales, for then there was first a surplus for export. The value of the crop in 1903 was £4,000,000, in 1905 £3,000,000, and in 1907 £3,500,000. The total crop in the Commonwealth in the latter year was worth £9,777,629.

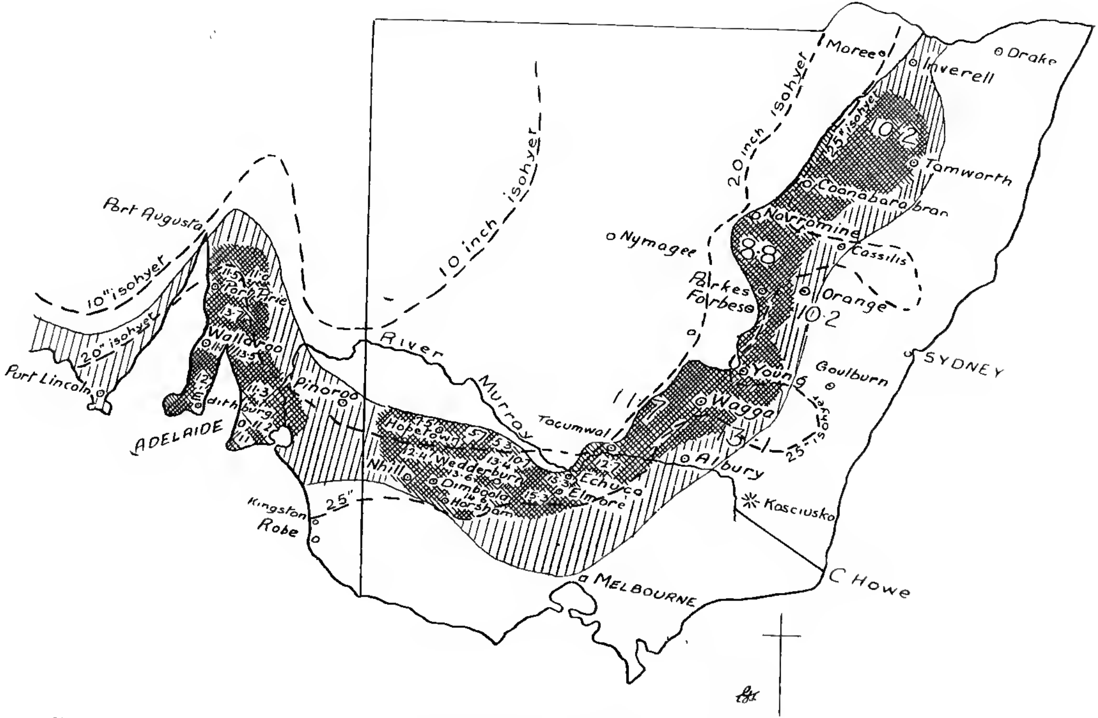


Fig. 41. Wheat Map. Figures show bushels per acre of districts (N.S.W.) and counties (Vic. and S.A). Chief areas strongly shaded.

In the *Year Book* of New South Wales the following is given as the relative importance of areas under crops in 1905.

Wheat Districts.	*Acres.*	*Bushels per acre.*	
1. Riverina (Tocumwal to Wagga)	620,616	11·7	Shown on Fig. 41
2. South-west Slope (Wagga, Young)	350,780	13·1	
3. Central-west Slope (Forbes, Coonabarabran)	343,928	8·8	
4. Western Plains (Narromine)	249,360	8·1	
5. North-west slope (Tamworth, Moree)	217,992	10·2	
6. Central Tableland (Goulburn to Cassilis)	113,636	10·2	
7. Northern Tableland (Tamworth to Drake)	14,546	14·6	

The following account is derived from the same work.

The great bulk of the wheat is grown on the western slopes and in the eastern part of the Riverina—these two districts together embracing nearly 80 per cent. of the whole. On the coast, in the Western Division, and in the Central-western Plain with the exception of the eastern fringe, the wheat area is very small. The whole of the recent expansion of the crop in the western plains is accounted for by the increase around Narromine. (See Fig. 41.)

It is, however, possible that a more rigid definition of successful farming might even exclude districts now placed within the wheat area. For example, several districts along the edge of the line such as Tocumwal, Wagga, Temora, Young, and Parkes have been included, although results have been doubtful; two, and, in some cases, as many as four failures having been recorded in ten years.

In some of the northern districts within the line much of the land is considered unsuitable for wheat-growing, consisting of stony, hilly country, unfit for cultivation, and of black soil plains which bake and crack and present mechanical difficulties in tillage. The rich soils of river flats must also be omitted from good wheat-growing areas, as such land has a tendency to produce excessive growth of straw, which, however, makes excellent hay. Excluding the coastal tract, where wheat growing has been practically abandoned during recent years owing to liabililty to rust, the area comprised within the wheat belt and suitable for its cultivation has been estimated to cover from 20,000,000 to 25,000,000 acres. The area actually under wheat is almost 2,000,000 acres, which is only one-tenth or one-twelfth of the total mentioned. Compared with the principal wheat-growing countries of the world the average yield of 10 bushels per acre is very small, since the United Kingdom has an average of 30·6, Germany 26·4 and Canada 20. But during 1905 Australian wheat had a higher value than that from any other country, being quoted at 32*s.* 4*d.* per quarter, or 2*s.* 8*d.* higher than English wheat. During 1904 New South Wales exported over 12,000,000 bushels of wheat, and the Commonwealth as a whole 38,500,000 bushels.

The greatest area under cultivation in **Victoria** lies in the north and north-west, in the Wimmera, Mallee, and Northern districts. The eleven north-west counties—Lowan, Borung, Kara Kara (Wimmera); Weeah, Karkarook, Tatchera (Mallee); and Gunbower, Gladstone, Bendigo, Rodney, and Moira (Northern) contain 93 per cent. of the area under wheat in Victoria. In 1905 over 2,000,000 acres were devoted to wheat, giving an average of 10·03 bushels per acre for the State. The average yield per acre for the chief wheat *counties* is shown on the map. There has been a falling off in the Wimmera and Mallee districts of late, where the tendency is for growers to combine sheep farming with cultivation.

Recent investigations in the Mallee country have shown that many acres suitable for wheat cultivation are awaiting exploitation—while over the border, in South Australia, the rainfall seems sufficient around Pinnaroo to justify the settlement which is being advocated by the Government authorities.

In **South Australia** there is a northward bulge in the isohyets, caused by the Flinders Range and possibly influenced also by the long gulfs running 200 miles into the continent. Here six counties around St. Vincent Gulf each produced more than 1,000,000 bushels for the season 1906–7. These were Daly, Stanley, and Victoria (which are entered at Wallaroo and Port Pirie); Dalhousie and Frome (between Port Pirie and Port Augusta); and sixth Fergusson, comprising Yorke Peninsula (with Edithburg for the chief port). Much wheat is also grown across Spencer Gulf, on the coasts of Eyre's Peninsula, where the chief town is Port Lincoln.

During 1907 South Australia exported wheat worth more than £2,000,000, and nearly £500,000 worth of flour. The following table gives the proportions shipped from the chief ports during 1907.

	Bushels.
Port Adelaide	4,237,631
Port Wallaroo	2,696,133
Port Pirie	2,612,716
Port Augusta	930,787
Port Germein	715,360
Port Victoria	525,976

In South Australia three-quarters of the rain falls in winter, the summer is warm and dry and periods of several months without rain are frequent. These conditions are very suitable for harvesting the wheat crop. Cereals are sown in April and May and make most of their growth before summer sets in. The warm weather of early summer

(October—November) brings the crop to maturity, usually resulting in the production of a bright heavy grain, highly appreciated in the world's markets on account of its dryness and the colour and quality of its flour. The nature of the summer, except in the cooler districts, militates against the cultivation of summer crops on an extensive scale except with the aid of irrigation, and consequently the skill and energy of the farmer have been mainly directed to the growing of winter cereals and the breeding of stock.

The following rainfall record for 1907 for one of the typical wheat-growing districts in South Australia will give the reader an idea of the distribution of rain in its relation to the cereal crop.

	Inches.		
January	0·00	(see p. 50 on *seasonal* rainfall)	
February	0·93		
March	0·29		
April	3·07 (Sowing)		
May	1·06 (Sowing)		Total rainfall during period of growth of crop. 12·08 inches.
June	1·36		
July	2·88		
August	2·79		
September	0·70		
October	1·33		
November	1·96 (Harvest)		
December	0·67		
	17·04		

Under conditions such as these crops of 30 bushels to 40 bushels per acre have been reaped by many farmers during the past few years from land worked according to scientific principles. A newcomer from the Old Country landing in South Australia, say in January, after a period of dry summer weather, would probably find the parched appearance of the fields uninviting and would form a poor idea of the capabilities of the country were he not acquainted with our records. As far back as 1838 Captain Sturt publicly warned the settlers that to attempt to cultivate the land on the Adelaide plains would result in disaster. This same land now is probably worth for cultivation purposes an average of £15 per acre, while a very large proportion of it realizes £40 and more per acre for the growing of green crops, fruits, and vegetables.

Of late years there has been a slight falling off in the quantity of land under wheat. This may be attributed to two causes. Firstly, twenty-five years ago a large area of northern country was broken up by the wheat grower, but experience having shown that much of this land was better adapted for grazing, a large proportion of it is now utilized for dairying and for sheep. Secondly, the farmer has recognized that it is more profitable to sow smaller areas of well tilled land than a large acreage unsufficiently prepared. In 1906 the percentage of fallow had reached 51·7.

It may be noted that the aim of the farmer in the comparatively dry areas, is as far as possible to utilize the rainfall of two winters for one season's crop. This is secured by the adoption of a three years' rotation, viz. grazing, bare fallow, cereals. After the cereal crop is harvested, stock graze on the stubble and the pastures during the ensuing eighteen months. The land is then ploughed up early in the winter to permit of the rains penetrating deeply and to avoid loss of moisture by running off. This having been done, the surface of the land is kept loose and fine during the following spring and summer, experience having proved that a dry earth mulch is a great factor in retarding the evaporation of soil moisture. The following winter the land so treated is sown to cereals.[1]

As in the United States it will be noticed that the

[1] The above account is from a Government publication, *Notes on Agriculture in South Australia*, 1908, which should be consulted.

wheat limit is gradually moving west. The cautious statements of the Government report indicate that this cannot be pushed much farther. The great irrigation scheme of Barren Jack, will extend the area considerably in the Riverina. The other large wheat-growing areas available would seem to be around Pinnaroo and Eyre's Peninsula in South Australia, while Western Australia has immense timber areas which will grow excellent wheat when cleared. Of course the chief increase will be due to a more thorough cultivation of areas already more or less exploited, and to improvements in such. A comparison with India as a wheat country shows that there the chief area lies between the 10 and 40 inch isohyets, and the 55° and 65° F. winter isotherms. In Australia, we find that these enclose an area which includes the Upper Darling and its tributaries, and extends almost to the tropic of Capricorn. So that in the future, irrigation may convert this into a granary such as obtains in India, though at present little wheat is grown in Queensland.

CHAPTER XVII

SURFACE WATER IRRIGATION AND SUPPLY

THE future of the larger portion of Australia is controlled by the question of water supply. Reverting to the Rainfall map of Australia (Fig. 13), it will be seen that 36 per cent. (perhaps more) of the continent is included within the 10 inch isohyet. Little can ever be done to reclaim this vast arid region, but around its borders, especially near the few large rivers, very considerable areas have been and will be rescued from the sterile and useless moiety of the continent. We have seen that a large area in the north-east lies within the Artesian Basin, and here, therefore, nature has supplied water underground. In this chapter, however, we shall deal with supplies obtained from rivers or carried from natural bodies of water in sluices or pipes.

The chief irrigated areas are naturally situated where the more populous regions abut on the arid central region, i. e. in the south-west and south-east of the continent. In the Murray Basin, in New South Wales and Victoria is gradually arising a comprehensive scheme of water supply extending from Bathurst to Ballarat. In Western Australia there is a water scheme developed to cope with the unusual arid environment of that State's chief industrial centre—the Coolgardie Gold-field.

Irrigation in the Murray Basin.

This portion of Australia contains almost one-fifth of the continent, and with the narrow strip between the basin and the sea, supports three-quarters of the population of Australia. Yet this huge area has only 1 per cent. of the population of Japan, an empire which is not much bigger than Victoria and but half the extent of New South Wales. It therefore behoves Australians to make

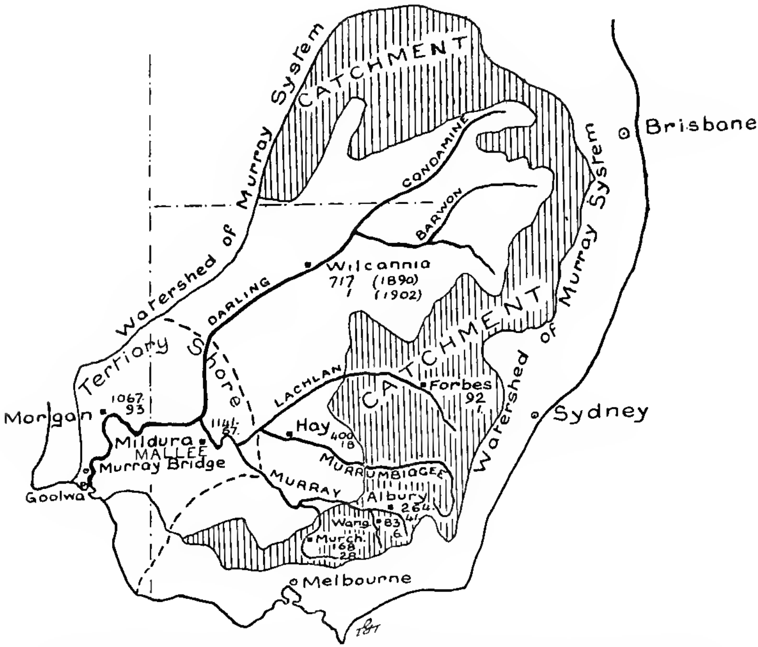


FIG. 42. The Murray-Darling Basin (after R. Mackay) showing the *effective* Catchment Area (shaded). The greatest and least annual flow (in thousand million gallons) at the important river towns is indicated also.

the best use of this land, the greater part of which, although its rainfall is much less than that of Japan, is of economic value, and has a soil in many districts unrivalled for fertility and depth. In a valuable monograph by Robert

T. McKay on the Murray River[1] it is stated that its basin occupies 414,253 square miles, while the effective catchment area comprises only 158,499 miles or about 38 per cent. As Mr. McKay states, however, the main factor militating for ever against a close settlement is that the quantity of water needed for irrigation is so great, that the land which requires irrigation for fertility will always be in excess of the capabilities of the water available for irrigation.

In Fig. 42 the amount of available water (in thousand million cubic feet) is indicated for the highest and lowest years. With such variations, conservation is absolutely necessary, otherwise ordinary supply canals for irrigation will be empty in time of drought when the supply is most needed. Thus on the Lachlan in *one month* (July) during 1900 more than 19,000,000,000 cubic feet passed the gauging station at Forbes. Yet in the *whole* of 1902 only a little more than 5 per cent. of this volume (1,000,000,000) flowed down the river, which indeed was a mere string of water-holes during the greater part of that year. Contrast also the results at Wilcannia (on the Darling) for 1890 (717,000,000,000) and 1902, when the river ceased for eleven months (709,000,000). Similar figures are given for the other chief river towns.

There are no tributaries joining the Murray in South Australia, and it has been computed that of the total in the main stream New South Wales contributes 293,000,000,000 and Victoria only 153,000,000,000, or approximately half the supply of the Mother State,

[1] A lecture delivered before the Sydney University Engineering Society on August 19, 1903. This lengthy and exhaustive paper is illustrated by numerous photographs and maps, and as the reprint is not widely circulated the present writer has ventured to make considerable use of it.

though Victoria has so far been much more progressive in the matter of irrigation.

Unfortunately the whole of the drier portions of the Basin (with rainfall less than 20 inches) cannot be irrigated. Obviously only comparatively low-lying land can be watered in this manner, and only suitable soils are worth the expense. Fortunately the Murray tributaries in their lower courses flow over a vast alluvial plain, partly estuarine and partly fluviatile in origin. A large estuary in late geological time extended as far as Balranald and Menindie (shown in Fig. 42 as the tertiary shore), and this received river silts and mud brought down by the ancestors of the modern Murray tributaries. The whole has been elevated in the late tertiary times, resulting in the 'Mallee' country around the confluence of the Darling and Murray.

The topographical features have made it easier for Victoria than for New South Wales to utilize the waters of its rivers. The catchment area is nearer to the irrigable flats and in general at a higher elevation, leading to less costly pipe lines and channels.

Irrigation in Victoria.

The chief areas which have benefited by irrigation (with one exception) are all situated in the northern lowlands of Victoria. Here the Victorians have spent £6,000,000 in remunerative works, chiefly on reservoirs and their attendant channels. Some 276,000 acres, about one-tenth of the area controlled by the various irrigation trusts, is irrigated.

The four chief river systems affected are the Wimmera, Loddon, Campaspe, and Goulburn (see Fig. 43). On the latter river a large weir has been constructed 8 miles above *Murchison.* It raises the water level 45 feet and supplies 600 farms in the Rodney district, with the result that during the great drought the farmers were fattening stock and supplying fodder to the starving Riverina just across the Murray.

At *Laanecoorie* (close to Poseidon, famous for the gold

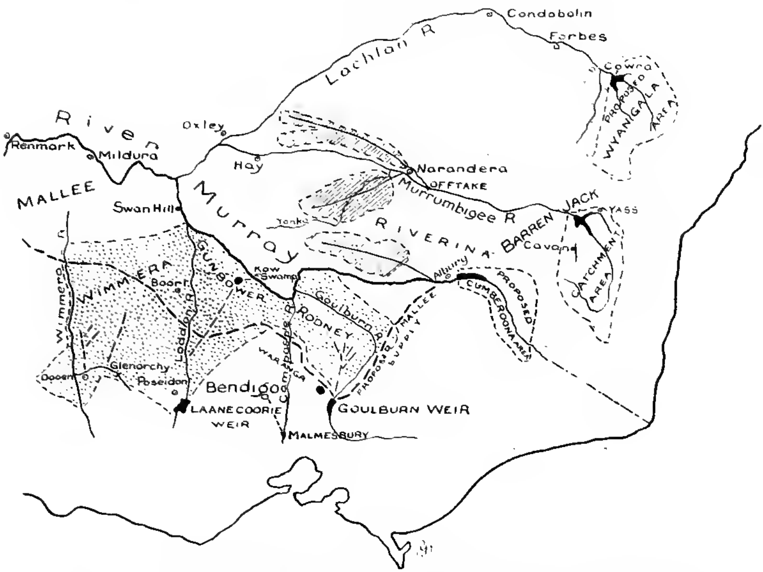


FIG. 43. Irrigation Areas of Victoria (actual) and New South Wales (projected) (after R. T. Mackay).

rush of 1906–7) a weir sends the water up the Loddon River for 5½ miles. It maintains the supply of the Boort irrigations and Bullock Creek Water Trust.[1] At *Malmesbury* on the Upper Campaspe is a group of works which supply water to the great mining centre at Bendigo. It is

[1] A Water Trust is formed to supply water for stock and domestic purposes, where the supply is not sufficient for extensive irrigation.

stated that the latter town has a cheaper supply for its mines than almost any other, and is thus enabled to profitably treat low grade ores.

At *Kow Swamp* on the Murray, below Echuca, are works costing £200,000. They carry Murray water into a reservoir, whence it can be diverted to irrigation areas in Gunbower. In dry weather the lower Loddon can be supplied from this reservoir.

On the Upper Wimmera are two schemes. *Glenorchy* supplies the Wimmera Trust by means of Richardson Creek; and *Dooen* Pumping Station is connected with a canal network of 155 miles to the north in the Western Wimmera.

The larger portion of the area defined on the map is held by the Water Trusts, and the three main areas under Irrigation Trusts are Western Wimmera (Dooen), Boort-Gunbower (Kow Swamp), and Rodney (Goulburn).

In the north-west of Victoria, where the rainfall is less than 16 inches, the tributary rivers are naturally of no importance, for instance, the Wimmera never reaches the Murray. As there is no local water supply, it is proposed to carry a channel from near Albury on the Upper Murray, where alone in Victoria there is more water than is needed locally, across Northern Victoria to the arid Mallee country of the Lower Wimmera. This is shown on the Map 43.

The great fertility of the soil when supplied with water is shown by the results at Mildura and Renmark on the Murray River, near the South Australian border. Of the former town it has been stated that an area of 8,000 acres is supporting 5,000 people, giving annual crops worth £120,000, while without irrigation the same area would not afford pasture for 1,000 sheep.[1] At Renmark there is

[1] *The Nile of Australia*, by D. J. Gordon, Adelaide, 1906.

a prosperous settlement where peaches, apricots, raisins, olives, and citrus fruits are grown. The water is pumped from the Murray. In 1901 the exports were valued at £29,474. Fifteen inches of water per acre per annum can be supplied for 12*s*. or less. These settlements seem fairly established on lines of steady profit from steady work.

Irrigation in New South Wales.

It is only lately that the Government of New South Wales has wakened up to the necessity of conserving the river waters, which when in flood are a source of actual damage as well as of potential loss. Private enterprise has shown the way. Sir Samuel McCaughey near Narandera has given a striking example of the economy of irrigation. He has estimated that two-sevenths of the waste flow of the Murrumbidgee would irrigate over 2,000,000 acres for cereals to a depth of 4½ inches. This should give 40 bushels of wheat to the acre, or a gross return of nearly £9,000,000 (cf. D. J. Gordon).

The results obtained by this stock-owner have largely influenced the Government policy. Now one large scheme is being carried out on the Murrumbidgee River and two others are proposed on the Lachlan and Murray respectively (see Fig. 43).

The *Barren Jack Dam* is situated on the Murrumbidgee, a little below Yass. Here the river narrows to a gorge below the 'precipitous mountain' (which is the meaning of the native name Booren Yaick). The drainage area is 5,000 square miles, and the dam will conserve all the most important inflows except that due to the Tumut River. The dam will probably be 200 feet high, and will store 20 square miles of water, or a much larger area than Sydney Harbour. The water will reach back over 40 miles up the main stream, and will thus form a magnificent artificial lake.

The river channel will carry the conserved waters for 200 miles, almost to Narandera. There an offtake will lead the water along the northern bank to the distributing canal, where it will flow for 100 miles through 750,000 acres of irrigable land, to Hay. On the southern side near the Yanco Cut another offtake will supply 912,000 acres to the west of Yanco Creek. The heavier soils will grow wheat, while vegetables and fodder (sorghum, maize, &c.) and fruits such as those grown at Mildura will undoubtedly flourish. The country is also suitable for tobacco and cotton.

It is estimated that the cost will be £1,279,000. This is a large sum, but it is a mere trifle when compared with the appalling loss in stock of 1902–3, which it has been estimated cost Australia nearly £130,000,000.[1]

Of the proposed reservoirs not yet authorized it will be sufficient to mention two, of which the first is *Cumberoona* above Albury, at the head of the Murray. Here a dam 70 feet high would impound two-thirds of the water held by the Assuan dam, and it would serve to water the level country around Deniliquin (see Fig. 43). In the central portion of New South Wales a second suitable catchment area (3,200 square miles, the same as Cumberoona) could be utilized at *Wyangala*, above Cowra, on the Lachlan. Assuming that a dam 155 feet high had been in use for 10 years prior to 1901, it would have been full at the end of that year, and instead of a dry channel beyond Condobolin there would have been a volume of no less than 20,000 cubic feet per minute available for stock and

[1] Vide R. T. McKay, *Agricultural Gazette*, New South Wales, Feb., 1907.

domestic supply as far as Oxley.[1] Thus thousands of sheep would have been watered during the great drought, and the dam would probably have paid for itself in that way, in a few years.

Western Australia.

In Western Australia nearly 400 miles inland from the coast, in a region which had before 1892 been crossed only by a few explorers and prospectors, where the rainfall (8 inches) is almost negligible, is clustered a community of mining men. The chief town, Kalgoorlie, has a population of 30,000, and the other large centres (Coolgardie, 15,000, Kanowna, 12,000, &c.) have a total of about 35,000. The question of water supply was one of great difficulty. At first, condensers were used to obtain fresh water from the local supply of brackish water in salt-pans and shallow lagoons. This, of course, necessitated the carriage of fuel, and the charge to consumers was nearly 7*s.* per 100 gallons. Naturally, this added enormously to the cost of living, and prevented profitable mining development.

It was decided to bring water from the wetter regions near the coast. Early in 1903 the present supply line was completed, connecting a reservoir near Perth with Kanowna, 387 miles east of that town. On the Darling Ranges near Perth there is a rainfall of over 20 inches and a weir across the Helena River (at Mundaring) impounds 400,000,000 gallons. Nine pumping stations elevate the water 1,313 feet to the Coolgardie distributing reservoir (see Fig. 57) at Bullabulling. The pipe line (33 inches diameter) is laid on the surface close to the railway, and at each of the pumping stations, roughly 40 miles apart, the water is elevated

[1] McKay, ibid.

about 140 feet, whence it flows by gravity to the next station.

The scheme[1] cost approximately £2,860,000, and can supply 5,000,000 gallons per day, though this is not required. The cost to consumers naturally increases with the distance; at Southern Cross (236 m.) it is 5*s.* per 1,000 gallons, Kalgoorlie (375 m.) it is 7*s.*, and at Kanowna 10*s.* per 1,000 gallons.

[1] An account of the scheme from an engineering point of view will be found in *Feilden's Magazine*, November, 1900.

SECTION III. MINING.

CHAPTER XVIII

METAL MINING IN AUSTRALIA

It is obviously impossible to condense into one small chapter a general account of the metal mining in Australia in sufficient detail to be of real value. It appears better, therefore, to choose a few representative mining areas in some of the States, and discuss briefly the essential elements of their geological and economic surroundings. The following somewhat arbitrary list will therefore be so treated[1]:—

(*a*) The gold-fields of Western Australia.

(*b*) The silver-lead-zinc area of Broken Hill, New South Wales.

(*c*) The Ballarat 'Indicator' Reefs, Victoria.

(*d*) The Alluvial 'Gold-rush' at Poseidon, Victoria.

(*e*) The Cobar Copper District, New South Wales.

(*a*) The Gold-fields of Western Australia.

Referring to the sketch-map (Fig. 44) based on the work of the Geological Survey of Western Australia, it will be noticed that that State consists very largely of very old rocks (archean possibly)—so old that the fossil contents, if ever there were any, have been altered beyond recognition. Large areas of granite and the allied rock gneiss also occur.

[1] Almost all the large mines are mentioned in the introduction (pp. 22-4). Further details are also given in the section on Railways.

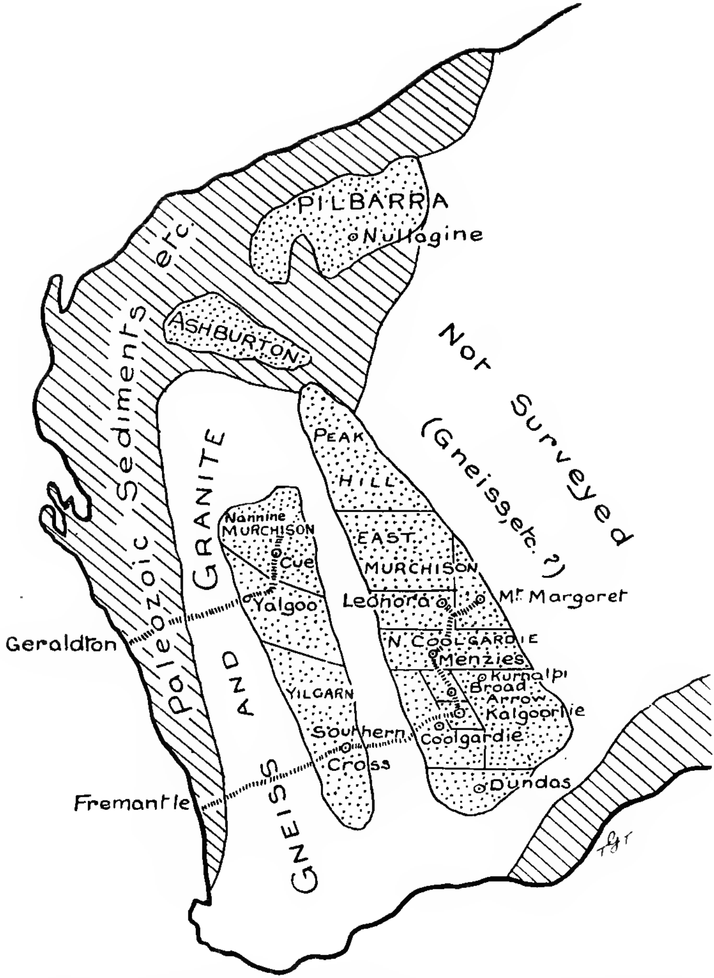


Fig. 44. Geological Sketch-map of Western Australia showing the chief Auriferous Areas (dotted). An important new gold-field is reported at Bullfinch, 20 miles from Southern Cross.

This primaeval 'massif' is fringed by later sediments both on the north-west and south (indicated by diagonal lines in the map), which from their fossil contents are certainly newer than the main 'massif', and may therefore be termed post-archean.

Crossing this exceedingly old series of rocks are two fairly well-defined belts running roughly from NNW. to SSE. They consist of dark laminated rocks in part, such as hornblende schists, and of various metamorphosed slaty rocks of an allied character. The more eastern belt includes the Coolgardie field (see Fig. 44), and possibly extends north to the Pilbarra field at Nullagine. The western belt—about twenty miles wide—extends from Southern Cross in a similar direction to Cue, and possibly farther north towards the coast.

There are numerous auriferous reefs in these two belts, though they are rarely well defined in the west. According to the official bulletin (No. 13) on the Leonora Gold-field, there are two main rock types present, a *granite porphyry*, containing a large percentage of silica, which passes into various altered products, but does not usually appear auriferous; and a darker *dioritic rock* ('greenstone'), which gives rise to the altered greenstone schists in which the chief gold reefs are found (see Fig. 45). The gold occurs in a somewhat exceptional form in many of the West Australian reefs. Usually gold is found nearly pure or alloyed with silver, but here it is often combined with tellurium—a substance allied to arsenic and sulphur.

'The lodes of Kalgoorlie consist of a series of almost vertical banded schistose formations (merely country rock more or less banded by dynamic changes) which have a general trend of from North 30° West to North 50° West. These deposits are lenticular in habit, the lenses being often of great length. Instances occur which go to prove that some of these may reach over half a mile in length. As a general rule the ore deposits have no well-defined walls, but seem to pass insensibly into the surrounding rock. The lodes are often traversed by a network of quartz veins, which ramify in all directions. There is abundant evidence attesting the fact that the rocks have been subjected to profound dynamic action, which has resulted in the production of lines of weakness along which the mineral-bearing solutions have found a comparatively easy passage. The width of the ore bodies reaches 80 feet in places. The

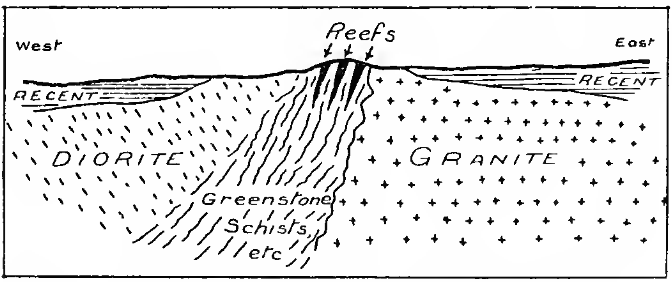


FIG. 45. Vertical Section across the Leonora Gold-field, Western Australia (from the Geological Survey of Western Australia).

gold occurs free, as tellurides, and as auriferous pyrrhotite.[1] The free gold presents such characters as point to its having been derived from the oxidation of the tellurium-bearing minerals; the decomposition of the auriferous pyrites may also be the source of some portions of it' (A. Gibb-Maitland, Government Geologist).

.At the outset, however, the deposits were discovered and worked as 'alluvial' fields. In 1892 Messrs. Bayley and Ford started on a prospecting trip eastward from Southern Cross (discovered in 1888) and reached the native well—

[1] Pyrrhotite is a sulphide of iron akin to pyrites.

Coolgardie. Here Ford picked up a half-ounce nugget, and before dinner-time they had found over 20 oz. of gold. A few weeks later they discovered the famous reef, and the same evening they picked up and dollied (i. e. roughly separated) with a tomahawk from the cap of the reef over 500 oz. of gold. Kalgoorlie was discovered by Messrs. Flannigan and Hannan in June, 1893. A large amount of alluvial gold was quickly taken out and many rich reefs discovered. Menzies was discovered in 1894, and in January, 1895, there were over 2,500 diggers 'dry-blowing' (separating the gold from the sand, &c., by air currents) in the vicinity of Kalgoorlie.

The following table from the *West Australian Year Book* gives the relative proportions of gold won in the principal fields, up to 1904 (see Fig. 32).

	Ounces.		*Ounces.*
East Coolgardie (c)	5,846,949	East Murchison	440,829
Murchison	1,067,473	Dundas (c)	257,367
Mt. Margaret (c)	916,745	Yilgarn	241,896
North Coolgardie (c)	913,694	Broad Arrow (c)	236,267
Coolgardie (c)	724,256	Peak Hill	188,846
North-East Coolgardie (c)	597,122	Pilbarra	119,383

(c = Coolgardie belt.)

The total for West Australia was 12,000,000 ounces, which were worth nearly £50,000,000, nearly all having been obtained since 1892.

(*b*) Broken Hill Silver-Lead-Zinc Mines.

Although this celebrated mine is well within the State of New South Wales, yet practically all communication is carried on through South Australia. A glance at the map (Fig. 56) will show that the coast of Spencer Gulf in South Australia is only about 200 miles away, while Sydney is more than 500 miles, of which a great part lies in arid regions. This mining district was first pegged out in 1883. Shares were then sold for less than £100 which some six years later were each worth £2,500,000. The rocks of the district consist of highly altered slates and schists, which have recently been classed with the cambrian rocks of the Flinders Range. The lode itself stood out as a ridge of

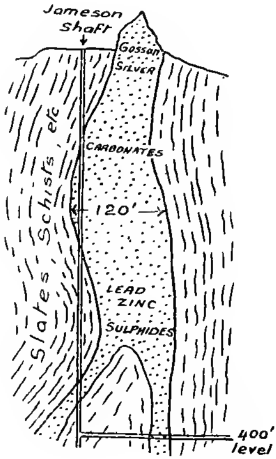


Fig. 46. Vertical Section through the Broken Hill Silver-lead Lode, showing the dominant Features (based on Pittman).

manganese-bearing rocks (gossan). It occupied a 'saddle-shaped cavity formed by the contortion of the strata, and its outcrop formed the highest part of the range for about a mile and a half of its length'.[1]

It appears possible that the lode is a *saddle lode* with two legs diverging downwards and outwards from the cap.

[1] Vide *Mineral Resources of New South Wales*, by E. F. Pittman, F.G.S., &c., where a concise general account of the mines may be read.

Other writers, notably Professor Gregory, doubt the definite saddle-lode structure and regard it rather as a variety of fissure vein. Of course the importance of the 'saddle-lode theory' is that there is a possibility of the occurrence of similar deposits at lower levels where similar cavities—due to the contemporaneous folding of lower strata—may have allowed the deposition of metalliferous bodies. Such recurrence has been proved in the Bendigo gold reefs in Victoria, and the rich 'caps' crowning the folds here lie at well ascertained levels, one below the other, but it may be remarked that the Broken Hill saddle is by no means so well defined as the saddle-reefs of Victoria.

Broken Hill is a good example of the occurrence of the richest bodies of ore at the *surface*, which is opposed to the miner's belief that the chances are in favour of an increase in value with depth. The surface claims were originally taken up for tin in 1883. They were found to contain slugs of 'horn silver', yielding 55 per cent. of the precious metal. The ore at the upper levels consisted chiefly of carbonate of lead with kaolin and other siliceous material, and yielded from 5 to 300 ounces of silver per ton. In this zone, owing to the changes in the ore-body due to atmospheric oxidation and removal of some of the less valuable materials by solution, the metals were more concentrated and more easily extracted than at lower levels. The ore-bodies below the 'oxidized zone' were found to consist of sulphides of lead and zinc, with a garnet-bearing siliceous matrix or 'gangue'. Here the character of the ore had changed, for zinc reached a percentage of 28, and exceeded that of any other constituent. As the richer ores are practically exhausted and silver values are decreased, it is obvious that the profitable extraction of zinc is now the chief problem of Broken Hill. This has been found possible by means of electro-magnets in Wetherill separators, since the zinc blende contains a notable proportion of iron. The process is described in some detail by Mr. Pittman in *Mineral Resources of New South Wales*, to which the reader is referred.

It is perhaps a legitimate exaggeration to say that Bróken Hill started as a *tin* mine, became a *silver* mine, then a *lead* mine, and now depends on the *zinc* for its profitable working.

The population of Broken Hill is over 28,000 (1906), and the aggregate output of the mines in little over twenty years was valued at nearly £38,000,000. This settlement in the desert is worthy of some attention from an economic point of view. The annual rainfall is only about 9·5 inches, so that agriculture is impossible. The Broken Hill district forms portion of a pastoral area (pp. 98 and 130–1), but it has such arid conditions that, as the Government report states, 'large flocks must be carried to render the holdings profitable, and the western squatter does well to have a substantial sinking fund against the *converse* of a "rainy day".' Hence even the pastoral industry is confined to a few large station holders. The South Australian Government, however, recognized the importance of the mineral field, and by a rapid extension of their railways captured all the trade connected with the industry. A railway of some 230 miles carries the ore and crude metals to Port Pirie (see Fig. 56). It is 150 miles farther to Adelaide. On the other hand, it is probable that a railway will be constructed from Broken Hill *via* Wilcannia to Cobar, a distance of 300 miles, for the most part across the level western plains, and thus link it to Sydney. In addition it will form a new through route from Sydney to Adelaide, but one which is not likely to compete with the present journey of some forty hours *via* Melbourne.

(*c*) The Ballarat Gold Reefs.

A very interesting gold-field in Victoria surrounds the towns of Ballarat and Bendigo. Apart from their present commercial importance, they are noteworthy as being the centres of the gold rushes of the fifties which had so much to do with the first real emigration to Australia. The country consists of silurian slates, which have given rise to undulating thinly timbered highlands. These slates are much folded and faulted, and are covered in the valleys with alluvial clays derived from them by weathering. Permeating the slates are numerous quartz veins, undoubtedly due to the deposition of silica on the cooling of underground waters. These veins sometimes contain gold, which has also been partly worn away and deposited in pockets on the surface of the rocks with the clay. Hence we have two classes of gold; that occurring in the *reefs* together with much quartz, and found at all depths as far as the shafts have been sunk; and the *alluvial gold*, which occurs in shallower deposits, freed from much of the quartz 'gangue'.

As an example of the reef gold the Ballarat 'Indicator' reefs may be instanced; while the biggest 'rush' of late years at Poseidon gives a good idea of the way alluvial is worked. (See (*d*) below.)

Ballarat is an exceptionally well favoured mining city. It has a rainfall of 27 inches, the same as the central plain of England, and an elevation of 1,400 feet. It is very healthy. Large crops of potatoes and oats are grown. Gold, however, is the most important asset, and over £70,000,000 have been obtained.

The alluvial diggings where many of the largest nuggets were found are not very important now. Most of the gold is won from the reefs. Some of the shafts are over

2,000 feet deep, cross-drives being cut at intervals to tap the various quartz veins or reefs. One peculiarity in many of the mines is the presence of the 'Indicator'. This is a band of carbonaceous shale, often containing some pyrites, which is interbedded with the slates. The latter lie more or less vertically, for the strata have been much folded. The quartz veins in many instances form more or less horizontal sheets, which cut the slates at right angles. In general, however, it is only where the quartz reefs are intersected by the indicator that valuable gold 'pockets' and 'bonanzas' occur. Here the quartz is extremely rich and the gold can readily be seen glistening in the face of the workings, a by no means common sight in a gold mine. The dark layer in the slates (the indicator) can be traced for long distances, and so it acts as a guide to the miner. There are several of these indicators of varying width and they have tended to make gold-mining at Ballarat a less uncertain and haphazard undertaking than is usually the case.

Undoubtedly the presence of the gold is due in part to the precipitating action of the 'indicator' band on the gold-carrying solutions, which percolated along the crack now occupied by the quartz reef. Experiment has shown that gold will deposit from solution on carbonaceous matter as well as on many metals and metallic compounds, a fact of which advantage is taken in several methods of gold extraction. In the figure annexed (Fig. 47) it will be noticed that the quartz vein occupies a fault plane where the slates have been cracked across and displaced to one side. This is very usual, the gold-bearing solutions naturally finding their way along old lines of weakness.

(*d*) Alluvial Gold at Poseidon.

At the height of the 'rush' early in 1907 the writer and a friend visited this field, which is situated near the Loddon River, twenty miles west of Bendigo (see map, Fig. 43). A short time before several large nuggets, one worth more than £3,000, had been obtained; but such finds are by no means as common now as they were in the fifties. Naturally, as the district lay so close to a town of 40,000 inhabitants,

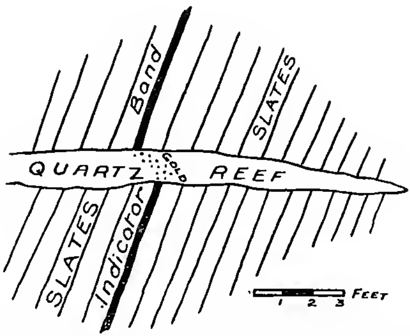


FIG. 47. Vertical Section in a Portion of a Ballarat Mine, showing the occurrence of the rich ore where the horizontal quartz reef cuts the Indicator.

it was quite settled. The lucky miners who got there first were for the most part farmers from the adjoining townships. They were well used to pick and shovel, for they often go 'prospecting' during the slack season at the farm.

The actual scene of operations was a large thinly grassed paddock, with numerous gaunt gum trees, under which the tents of the miners were pitched. A slight ridge marked the course of a quartz reef which had been worked out many years ago. Towards the end of 1906 a prospector put down auger-holes along a course parallel to the reef (as at A), until he found the underground rocky channel which had originally drained the ridge. Here he pegged out his claim, and in the stiff red clay, within a foot or two of the surface, dug up several thousand pounds worth of the rare metal. His friends immediately pegged out their 60 feet × 60 feet claims as close as possible to his. Those who happened to be on the line of the underground channel (or 'lead') were handsomely paid for their labours—those a foot away got practically nothing. The 'lead' rapidly deepened to 60 feet within half-a-mile, and here the gold was in smaller slugs and not so plentiful. The clay was

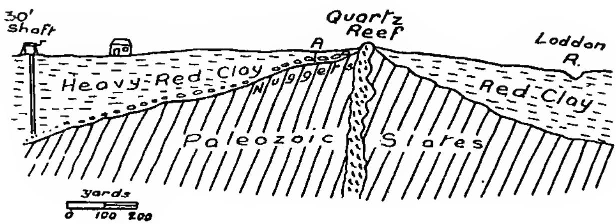


Fig. 48. Vertical Section of Alluvial Diggings at Poseidon, Vic., along the course of the underground channel.

dug up very carefully and carted a mile or more to the Loddon river, where it was washed in rather primitive circular timber puddlers. The clay was gradually swept away to the river, and the gold collected in the bottom of the puddler.

Two features stand out in the picture of this particular field. Although the miners lived in tents and had to buy their water at a penny a bucket, yet provisions and supplies could be obtained at ordinary prices from two stores, while bakers' carts called regularly from the neighbouring towns. Although owners of claims along the 'lead' made much money, many of the others were content to hasten slowly, and their holdings were merely 'shepherded' by agents from 11 a.m. till noon (when the law requires representatives to be on the claim) to prevent jumping. The owners were waiting until their neighbours' work should reveal whether it was worth while to pay the extra charges for actually 'breaking ground', and to sink the shaft which was necessary to reach the gold above the bottom rock.

(*e*) The Cobar Copper Mines.

Just as the discovery of the valuable silver-lead ores of Broken Hill led to the profitable settlement of the extreme Western portion of New South Wales, so the presence of large masses of copper ore at Cobar has contributed greatly to the opening up of the middle west of the State. If the reader refers back to the section dealing with the main geological features of New South Wales (Fig. 29), he will find that Cobar is situated just where the palaeozoic rocks (which constitute the Eastern Highlands) emerge from the later sediments which cover their flanks. The region is akin to the Highlands, but not of them, for it is a comparatively level plain with no hills of any importance. As the rainfall is under 15 inches and the soil poor, the vegetation consists chiefly of isolated eucalypts or stunted gum scrubs.

Owing to the valuable mineral contents of this barren surface it has become one of the most important mining centres in Australia; since in addition to Cobar, Nymagee, and numerous other copper properties, many gold mines such as Mt. Boppy (perhaps the most important in the State) have been opened up in recent years.

Although the main Western railway line extends to Bourke, yet by far the greater traffic branches off at

Nyngan to Cobar and its neighbours. The great demand for fuel for the blast furnaces has led to the destruction of all the larger trees for miles around, so that the district has a blighted appearance. Yet in a good season wheat will grow—and the writer vividly remembers the bright green appearance of a field of young wheat, though no grass was visible in the neighbourhood. The ore was discovered in 1869, owing to the presence of green and blue stains in a native well. It was extremely rich as may be gathered from the fact that in spite of the cartage of over 250 miles to the railway, handsome dividends were obtained.

It is very interesting to remember that at this period several thousand tons of ore were sent by team to *Bourke* and thence down the Darling and Murray by steamer to Adelaide. So that at first Cobar, like Broken Hill, was commercially nearer to Adelaide than Sydney. Now the railway from Sydney extends a little beyond Cobar. The Company has a refining plant at Lithgow, about 350 miles away near Sydney (see p. 190), hence it is evident that the Cobar traffic bulks considerably on the main Western line.

As in Broken Hill and most copper and lead mines the character of the ore varies with the depth. The walls enclosing the ore-body consist of altered slates, probably silurian in age. The ore masses are much wider at the deeper levels than the outcrop would indicate, a fortunate but rather exceptional condition. The upper portions consist of copper carbonates with a more or less ferruginous gangue, lower down at 250 feet the carbonates and oxides are mixed with the unaltered sulphides, while at the lowest levels (over 600 feet) the stopes (or workings) are cut in solid masses of yellow copper pyrites. It is a strange experience to visit these huge artificial caverns, one of which in 1904 was 370 feet long, 25 feet high, and 60 feet wide. They are comparatively free from timbering, since the ore 'stands' well without support. In these large spaces, however, it is difficult to work the ore, and sooner or later probably the empty stopes will be filled with 'mullock', or waste material obtained during mining operations.

The ore is smelted in blast furnaces at Cobar with a certain proportion of siliceous gold ores to a 'matte' or compound of copper and sulphur containing about 30 per cent. copper and all the gold and other metals. This is trucked for 350 miles to Lithgow, where the Company owns a refining plant which is actually built over the outcrop of the Western Coalfield. Here the 'matte' is smelted in reverberatory furnaces, in which the intensely hot combustion products from the fuel are 'reverberated' from the roof of the furnace on to the large flat hearth whereon the ore and fluxes lie. By this treatment the sulphur and most of the other impurities are driven off. The impure 'blister' copper is cast into flat plates, which are refined electrolytically. They are hung in wooden tanks containing copper sulphate solution. On passing the current from a dynamo the copper dissolves from these impure slabs, and is deposited in a pure state on thin sheets of pure copper facing the slabs. The gold, silver, and other impurities collect on the tank bottom and can be easily recovered.

A brief account of some of the other important Australian mining fields will be found in the section dealing with the Railways of Australia, while the map (Fig. 3) of the history of gold discovery, shows all the principal gold mines.

CHAPTER XIX

COAL IN AUSTRALIA

In Europe and most of the coal centres of the Northern Hemisphere, the chief coal-bearing rocks are characterized by a fairly uniform set of fossils which have been termed *carboniferous* for that reason. In the Southern Hemisphere the most valuable coal is found in beds newer than these. This coal is assigned to an intermediate position, the permo-carboniferous. It is characterized by certain ferns with tongue-shaped leaves (*Glossopteris*). In Australia, India, and South Africa there are valuable coal deposits of this age, and these fields are also characterized by the presence of glacial boulders and other common features. The economic geology of the Australian coalfields therefore differs greatly from that of Europe, and beds which in Europe would be associated with coal are devoid of it in the Southern Hemisphere.

There are also coal-bearing strata in much younger rocks, but the coal is of a much poorer quality.

Coal, as opposed to most metalliferous deposits, occurs in more or less horizontal beds or seams. In most cases it is derived from the carbonaceous material of enormous swamps, peat-bogs, and coniferous forests, which were buried long ages since, by later silt and sand. Subsidence and further deposition has piled thousands of feet of fresh material above the ancient peat deposit, consolidating it, and often altering its constitution by squeezing out volatile matters, or leading to the dissemination of bituminous substances through the whole. In many cases no doubt the coal plants grew where the seam now lies, since the 'underclay' is often deficient in the amount of plant foods, and crowded with fossil roots. Often, however, ancient floods undoubtedly swept organic débris into some depression in the bog. The accompanying silt gave rise to those worthless 'bands' in the coal which so greatly decrease its economic value.

Coal in Australia, as elsewhere, varies very greatly in appearance, composition, and economic value. Before describing the chief deposits a few remarks on the method of testing and classifying coals will help the reader to appreciate their characteristics.

The value of coal is tested in the following manner. A definite amount is ground up and weighed. It is then heated to drive off *water* and weighed again. The poorer coals contain a very large proportion of water, which lessens their value as a fuel, since this must be evaporated before the coal is of use. Then the weighed coal-dust is heated red hot in a closed vessel which, however, permits the escape of the *volatile gases*. From diminution in weight the percentage of the latter can be calculated. The character of the residue shows if it be a *caking coal*; for then a vesicular lump of coke will have formed of a nature suitable for metallurgical purposes. Finally the coal is intensely heated with free access of air. This burns away all the *fixed carbon*. It leaves only the ash, which, like the moisture, is another deleterious compound, since it often contains substances injurious in metallurgy, causes clinkers in the grates, and is useless bulk in freight waggons.

A usual classification of coal based on the foregoing is as follows, determined by the percentage of *volatile gases* or hydrocarbons :—

Name of Coal.	*Percentage of Hydrocarbons.*	*Other Characters.*
Illuminating Coals . .	45–29 %	Should be low in sulphur.
Metallurgical (giving dense and coherent coke)	29–17 %	Should be low in ash and sulphur.
Steam Coals . . .	17–10 %	Used in boilers.
Anthracite	10 % and less	Smokeless and less bulky.

Distribution of Coal in Australia.

The States richest in coal are New South Wales, Queensland, and Tasmania. The first has by far the greatest output as the figures for 1906 show.

	Output.
New South Wales	£2,337,227
Queensland . . .	173,282
Victoria	80,283
West Australia .	57,998
Tasmania	21,158

Referring to Fig. 49 the main (permo-carboniferous) coal-bearing strata are seen to occur along the eastern shore of Australia. In north Queensland are three small basins of no importance at present, Oakey Creek and Little River, behind Cooktown, and at Townsville. Next comes the large undeveloped basin of the *Dawson River*, which contains excellent coal, some of it almost anthracite. Just within the New South Wales boundary is a relic of the eroded coal preserved at Ashford. South of this area is the most important coalfield, the *Newcastle-Lithgow-Bulli* Coal Seams, which, with their associated strata, cover an area of 25,000 square miles, and yield nearly £2,500,000 worth of coal per annum. In Tasmania unimportant fields of this age occur near the Mersey River in the north and at Port Cygnet in the south. The chief coal supply in this State is from later sediments.

Of deposits of later date, the most important occurs in

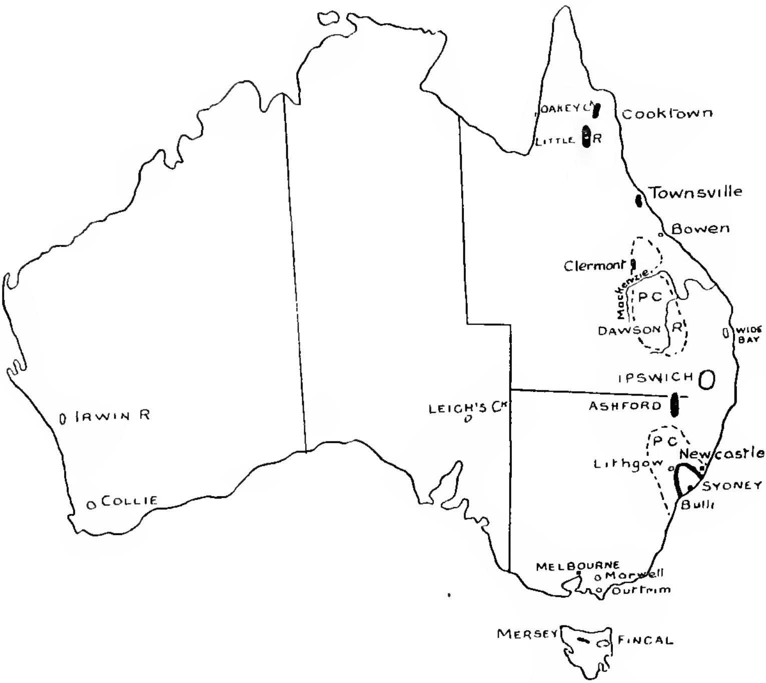


FIG. 49. Chief Coalfields (after Prof. David). Permo-Carboniferous (P. C.) seams are black.

southern Queensland around *Ipswich*. To the east of the permo-carboniferous basin there occurs an area of triassic coal which supplies the Queensland market, and has led to the establishment of a considerable manufacturing centre at Ipswich. In the southern extension of these deposits in New South Wales there are a few seams of no great value, which are by no means comparable either in extent or in composition with the Ipswich coal.

Of somewhat similar mesozoic age are the small deposits of *Leigh's Creek* in South Australia, where an enormously thick deposit of moist, poor coal is found, and the Gippsland coal at Outtrim near C. Paterson, Victoria.

More important mesozoic coals, however, occur in Tasmania and Western Australia. At *Fingal* in the east of Tasmania, a very flourishing coalfield occurs whence 90 per cent. of coal won in the State is derived. In Western Australia, a useful supply is obtained at *Collie* in the south-west corner. It lies in a small basin scooped out of the ancient 'massif' of Western Australia, and so has not been subjected to earth movements.

Where folding has taken place, the coal is as a rule more compact and contains less water and volatile matter. Hence the excellent quality of the Ashford coal (New South Wales) and of portion of the Dawson River coal (Queensland). But the undisturbed coal at *Collie* has not been improved by the 'kneading of Mother Earth' and is therefore very wet and somewhat clinkery.

Passing to the tertiary deposits, the main Victorian seams at *Morwell*, 88 miles east of Melbourne, are of this late period. The coal is friable and moist, and has therefore been 'briquetted' or compressed into bricks after being dried. In this condition its value is greatly enhanced, but even so it cannot compete with the Newcastle coals, except quite locally. These facts are summed up in the following table, which gives fairly representative figures but does not pretend to great accuracy.[1]

[1] In part based on data given by Professor David in a lecture to the University of Sydney Engineering Society.

Locality.	*Age.*	*Character.*	*Composition.*				*Potentialities.*
			Water	Vol. H.	F. C.	Ash	
Newcastle	Permo-carboniferous	Very good steam coal for boilers, domestic use, gas, &c.	1·9	35	54	9	Exported very largely, gives best coke.
Lithgow	do.		1·9	31·5	52·6	14	Not exported, as 100 miles from coast, used in metallurgy.
Bulli	do.		1	23	65	11	Used for coke and export.
Ashford, New South Wales	do.	Excellent coal	0·71	22·9	69	7·5	Useful on northern railway.
Dawson, Queensland	do.	Excellent coal, high % fixed carbon	3·7	13	78	5	Very promising field for export and local use.
Ipswich, Queensland	Trias	Used for all purposes	1·5	28	62	8	Two seams, 11 ft. and 4½ ft. Supplies all Queensland.
Collie, West Australia	do.	Hydrous, brittle when dried	15	25	53	6·7	Supplies West Australia.
Fingal, Tasmania	do.	Like Ipswich coal	—	—	—	—	Supplies Tasmania
Gippsland	do.	Poor coal	6	32	55	7	—
Leigh's Creek	do.	49 ft. of soft coal	17·7	27·3	42	13	400 mls. inland, very clinkery.
Morwell, Victoria	Tertiary	Very hydrous and crumbly	46	32	16	4	Usable when briquetted after drying.

As the chief coalfield in the Southern Hemisphere, some further details of the New South Wales Basin are shown in Fig. 50. This is a diagram representing a model cut across from west to east to show vertical sections along two lines.

In the west the basin is bounded by silurian (?) slates, which also form the bed rock below the coal measures. Immediately above this oldest formation comes the marine

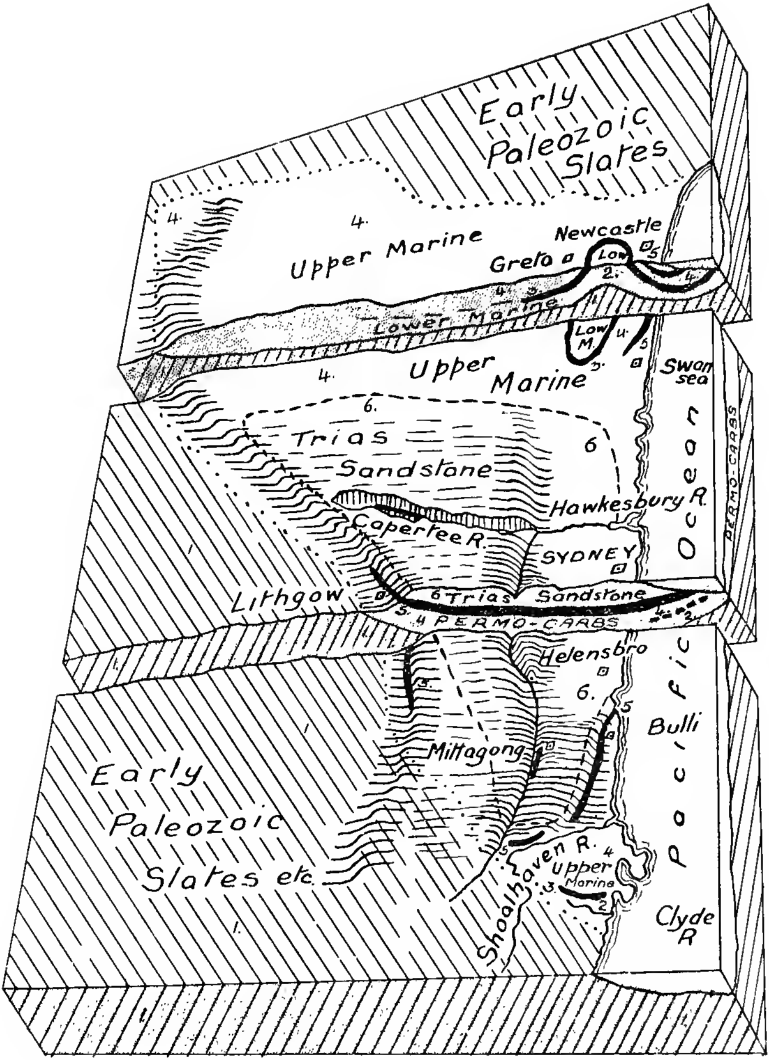


Fig. 50. Sketch-model of the chief Coalfield of Australia, showing the Relation of the Coal Outcrops (black) to the Scarps and Valleys of the Blue Mountains. It is cut across at Sydney and Newcastle to show the underground relations of the main seams. 1 = Silurian Slates enclosing Coal Measures (hatched); 2 = Lower Marine Permo-Carbs. Series; 3 = Greta Coal Seams; 4 = Upper Marine Series; 5 = Newcastle Seams; 6 = Trias Sandstone Capping.

series marked (2) known as the lower marine[1]; they are nearly 5,000 feet thick. Above it is the lower seam which crops out at Greta, where an upward bulge or dome in the crust occurs; it forms an important part of the field, for the workable coal is about 20 feet thick. It also appears far to the south at Clyde River, but is not yet worked there. Later 5,000 feet of the upper marine series (4) were deposited. Immediately above it lies the most important series of seams known as the Newcastle-Bulli coal, which seems to form a huge black saucer, extending under the whole of the country from Newcastle to Lithgow in the west and to Bulli in the south.

By remarkably acute geological induction, the credit of which is due chiefly to Messrs. Clarke, Etheridge, and David, it was inferred that this coal would be found a few thousand feet below the capital city, Sydney. In 1890 a bore was put down at North Sydney and struck coal at 2,801 feet. A company has since put down two shafts in Balmain, alongside Sydney Harbour, so that 'the largest ocean steamers can load their cargoes of coal from the colliery's wharf in Sydney'. To the south of Sydney, at Helensborough, this same seam is worked profitably at 850 feet. At Bulli and allied collieries the coal crops out at the side of the Coast Range, and can be seen as a broad black band.

On the western side of the field, the coal crops out in the deep gorges excavated by the rivers flowing to the Hawkesbury. Here adits[2] in the river valleys at Mittagong furnished coal for the first smelters of iron. At Lithgow, on the western flank of the Divide (see Fig. 50), the coal

[1] The lower marine series seems to have been overlapped by the upper marine series for a great portion of the basin. It outcrops best in the east, near Newcastle and the Shoalhaven River.

[2] An adit is a more or less horizontal passage usually opening in the face of a hill.

comes to the surface and has led to the rise of one of the chief manufacturing centres in Australia. Here is situated the only large blast furnace (Sandford's, 1907), and several metallurgical works chiefly connected with the copper industry.

Mr. E. F. Pittman (Government Geologist of New South Wales) has estimated the coal resources as follows:—

	Sq. miles.
Productive area of Upper Seam (Newcastle-Bulli) . .	15,800
Productive area of Lower Seam, in north (Greta) . .	250
Productive area of Lower Seam, in south (Clyde) . .	500
	16,550

The maximum thickness of workable coal is about 120 feet. Assuming there is only 10 feet of workable coal over the whole 16,550 square miles, he[1] estimates that there are 115,346,880,000 tons of available fuel, which is more than that of the coalfields of Great Britain.

In the Capertee valley, which opens to the Hawkesbury, is one of the largest deposits of kerosene shale in the World. It is shown as a black band in the cliff, in Fig. 50. A very large and important industry is arising in connexion with this mineral layer in the upper permo-carboniferous strata.

Overlying all the coal seams is an upper 'saucer' of barren sandstone of triassic age, of which the chief buildings of Sydney are constructed. On the west, owing to a great monoclinal fold of pleiocene date, the coal is brought to a considerable height above sea level. The rivers of the Blue Mountains have exposed these seams, which lie at the foot of the great gorges, 2,000 feet deep. It seems probable that the valley shapes are largely determined by the erosion of these softer coal measures underlying the hard sandstone capping (see p. 122).

[1] See *Mineral Resources of New South Wales*, by E. F. Pittman, A.R.S.M.

SECTION IV. OTHER INDUSTRIES OF AUSTRALIA

CHAPTER XX

SOME MINOR INDUSTRIES OF AUSTRALIA

In this chapter several of typical minor industries will be described. Those which present most points of interest, in the writer's opinion, are the following: Australian Timbers, the Sugar Industry, the Fisheries, and, finally, the Copra Industry.

The Timber Industry.

The only States which have developed a commerce in timber are Western Australia and New South Wales. The former exports timber worth more than £500,000 a year, but New South Wales only one-third of that. The western State has paid more attention to the exporting of timber, which is largely controlled by the English capital of the Jarrah Company. Although the timbers exported from the two States are almost all members of the Eucalypt family (allied to the myrtles botanically), yet the genera are quite distinct. For instance, *Eucalyptus crebra* (Ironbark), *E. microcorys* (Tallow-wood), *E. punctata* (Grey Gum) are very important trees in New South Wales; while *Eucalyptus marginata* (Jarrah) and *E. diversicolor* (Karri) are the chief timbers exported from Western Australia.

The eucalypts have lanceolate leaves, rich in essential oils, with both surfaces alike. The flowers are usually not very conspicuous and are generally greenish or white. They are great favourites with bees, and many a bare rocky slope which will only grow stunted gums is of value to the bee-keeper. When young the trees are very graceful and bushy, but unless topped, usually become somewhat gaunt and straggly in their old age. The local names are mainly based on the character of the bark—which is renewed annually. Thus the smooth barks belong to the *gums* (grey, blue, and red), the corrugated barks denote *ironbarks*, the fibrous barks are *stringybarks*. Their aromatic properties, quick growth, handsome appearance and valuable timber have led to their plantation in many parts of the world, such as California, New Zealand, South Africa, and Italy.

The eucalypts attain their most vigorous growth in temperate regions and require a fair rainfall, though many of them can flourish in dry surroundings that would dishearten any other tree. For instance, in the arid regions of South Australia (north-east of Lake Torrens) the country is largely a stony waste with a few stunted mulgas. Yet here and there a line of large eucalypts marks out a 'gum creek' or dry river, where the deep roots of the 'sugar gum' are able to tap the moist subsoil.

Western Australia.

In Western Australia, as elsewhere, the distribution of timber is mainly controlled by climate. It is bounded on the east by the desert and extends north to latitude 30° near the Irwin river (see Fig. 51). Within these limits are found splendid forests, of which the jarrah and karri are undoubtedly the most important. There are, however, several other timbers of great value. Along the coast, for instance, is a narrow belt of Tuart (*E. gomphocephala*). This tree attains a height of 160 feet and a diameter of 7 feet near the ground. It is specially suitable for framing, possessing a curly grain which makes for toughness.

The great Jarrah belt lies to the west of a line joining Perth to Albany, and chiefly on the eastern flank of the Darling Range. Its area is estimated at 8,000,000 acres. About 60,000 acres per year are cut, and it is considered

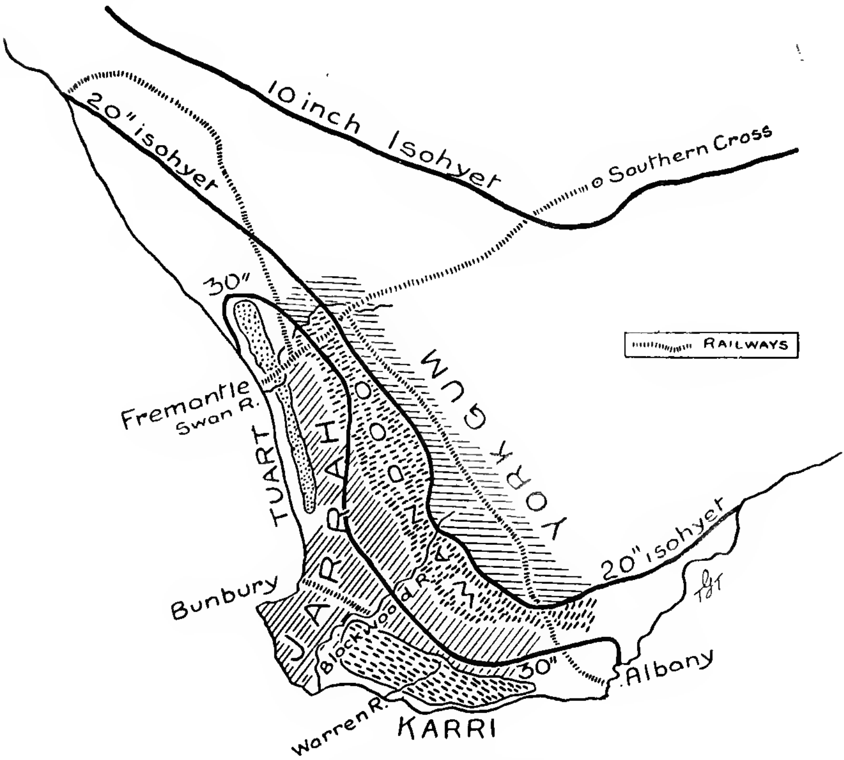


FIG. 51. Timbers of Western Australia.

that there are thirty years' supply. Though not such a large tree as the karri, jarrah is one of the most handsome and durable timbers in the trade. It constitutes by far the largest proportion of the timbers exported, for it is in great demand for street-paving and piles, while it makes excellent railway sleepers, probably unexcelled.

The Karri Forests lie to the south of the State, between the Blackwood River and Albany, the best occurring in the valley of the Warren where there are about 1,000,000 acres of this fine tree. It grows to a height of 200 feet and attains a diameter of ten feet at the base. It is very strong, tough and elastic, and is therefore well suited for bridges, shafts, and allied work.

On the eastern flank of the Darling Range are found two valuable trees, the Wandoo and the York Gum. They are smaller than the preceding, reaching a height of 75 feet, with a diameter of 20 inches. Both are dense hardwoods. The former is used largely for props in mining, and both are suitable for general wheelwright work. Their distribution with reference to the 20-inch isohyet is well shown in Fig. 51.

An estimate made some years ago put the areas as follows:—

	Acres.	*Loads.*
Jarrah . . .	8,000,000	40,000,000
Karri . . .	1,200,000	15,000,000
Tuart . . .	200,000	300,000
Wandoo . . .	7,000,000	7,000,000 (Wandoo and York Gum together)
York Gum, &c. .	4,000,000	
		62,300,000

The late Conservator of Forests estimated the value to the State of forests on Crown Lands at £124,000,000.

New South Wales.

Largely owing to the researches of Messrs. Maiden and Dalrymple Hay, the physiography of the timber areas in New South Wales is perhaps better known than in any other State. The accompanying figure shows how greatly the timber belts depend on rainfall (Refer to Fig. 52). The 10-inch isohyet defines the western limit of the forest area, and the 20-inch line the western boundary of the Highland timbers. In the north is a zone of Brush timbers of especial interest, on the eastern flanks of the New England Plateau. Along the coast is a well-marked province known as the Coastal Zone.

As might be expected, the various timbers are not altogether confined to any one district. For instance, ironbark is found all over the north and east of the timber area, and grey box has a similarly wide range. The yellow box favours the western slopes of the divide, while the stringybark is most common on the eastern. Blue gum, turpentine, and mahogany are practically confined to the coastal area. Murray red gum occurs only in the Riverina. Cypress pine is characteristic of the Western Plains where the forests are sporadic.

The most characteristic area is that known as the Northern Brush. Here are some of the largest areas of ancient lava (basalt) which make a fertile soil. This combined with the heavy rainfall in this region, has led to a forest growth far more luxuriant than anywhere else in the State. Here a sub-tropical flora, consisting very largely of soft woods, flourishes. The most highly prized is the magnificent red cedar, a timber of great value in ornamental joinery. Other woods with a beautiful grain are rosewood and tulipwood, while sassafras and yellow-wood, which also grow on the basalt hills of the Blue Mountains, are used in cabinet work.

The following table, due to Mr. J. H. Maiden, F.L.S., shows the economic characteristics of these timbers.

Name.	*Characteristics.*	*Use.*
Ironbark	Strength, durability, weight	Girders, sleepers, framing, shafts.
Stringybark	Easily split	Fencing and building, sleepers.
Mahogany (Blackbutt)	Strength and durability	Paving, building, sleepers.
Tallow-wood	Durability, greasy nature	Decking, girders, piles.
Grey Box	Toughness, coarse grain	Naves, mauls, sleepers.
Blue Gum	Straight grain, easily worked	Building, planking.
Turpentine (*Syncarpia*)	Resists decay and white ant, non-inflammable	Piles, sleepers, paving.
Murray Red Gum	Strength, durability, resists white ant	Piles, ground timbers, paving, sleepers.
	Soft Woods.	
Cypress Pine (*Callistris robusta*)	Durability, fragrance, resists white ant	Linings, framing. (Western Slopes.)
Red Cedar (*Cedrela Australis*)	Lightness, easily worked, handsome figure	Furniture, joinery. (North Coast.)
Rosewood (*Dysoxylon*)	Rose fragrance, and fine working qualities	Furniture, boxes, &c.
Tulipwood (*Harpullia*)	Toughness, ornamental grain	Cabinetwork, billiard-tables.
Sassafras (*Doryphora*)	Lightness, fragrance	Furniture, cases.
Yellow-wood (*Flindersia*)	Hard, close grain, like beech	Cabinetwork.

It is estimated that one-tenth of the State (about 20,000,000 acres) is covered with forests. More than half of this area occurs in the moister Coastal Belt.

So far the export of New South Wales timbers has been trifling. Ironbark girders and sleepers have gone to New Zealand and Britain; tallow-wood, turpentine, and blackbutt for paving and sleepers to New Zealand and Germany; and a little ornamental timber (rosewood, &c.) to Germany.

However, the Government is endeavouring to stir up interest in the immense supplies of hardwood. In ironbark New South Wales possesses probably the strongest timber in the world, which at the same time is one of the most durable.

The following table from a report issued by the Lands Department on Timber Export shows that as sleepers and

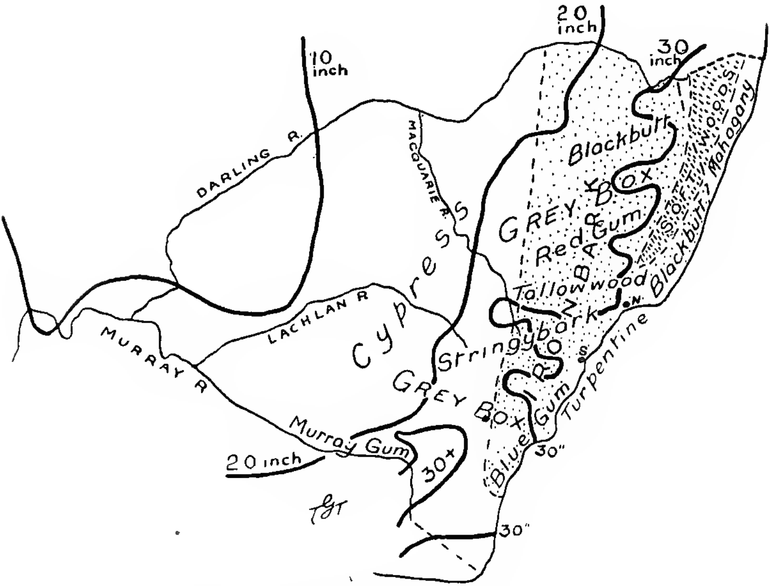


FIG. 52. Chief Timbers of New South Wales. Ironbark area is dotted. Isohyets also shown.

bridge girders our hardwoods are vastly superior to European timbers.

	Life as Sleepers.	*Bridge-work.*
Ironbark . . .	25 years	30-45 years
Murray Gum . .	20 ,,	
Tallow-wood . .	20 ,,	20–25 ,,
Stringybark . .	18 ,,	
Blackbutt . . .	16 ,,	20-30 ,,
Turpentine . . .	16 ,,	

Professor Warren of the Sydney University[1] has tested the strength of New South Wales hardwoods, using test-pieces 4 inches by 6 inches, and 4 feet long. He finds the breaking strength of these specimens, when loaded at the centre, to be proportional to the following numbers :—

Ironbark	18,000	English oak	9,762	For comparison.
Turpentine	14,000	Spruce	5,046	
Tallow-wood	10,000			

Sugar in Australia.

In Australia all the sugar grown is derived from canes. Attempts both in Victoria and New South Wales with beet sugar have failed, though the reasons are not obvious. Cane sugar flourishes best near or between the tropical regions, the chief regions being Cuba, Java, Hawaii, and the Philippine Isles. In Australia, however, we have extensive plantations south of the tropic which may be compared with those of Louisiana in America. Another centre of interest to Australians is Fiji, where sugar is the most important crop. It is evident that, given good soil and a satisfactory rainfall, a wide range of temperature is permissible in sugar-cane planting. This is the case in Australia, where the sugar industry extends from the Clarence River in New South Wales to Cooktown in North Australia, the mean annual temperature ranging from 68° F. to 80° F.

In New South Wales the sugar-cane is practically confined to the three northern coast counties (Rous, Clarence, and Richmond) centring about Grafton and Lismore. The southern limit is determined by the risk of frost, which has driven the planters northward. In 1895 there were nearly 33,000 acres under cane, but owing to increase in

[1] See *Report on Export of Timber for Sleepers in India.*

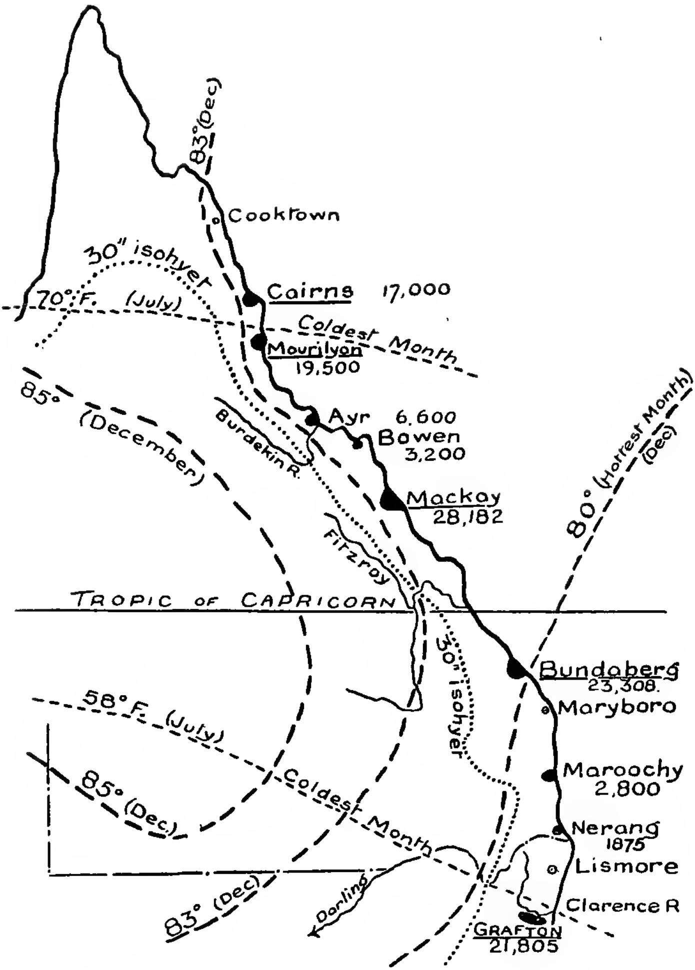


Fig 53. Sugar in Australia, 1905. (Figures denote acres under cultivation.)

dairying and changes in sugar duties the extent has decreased considerably since then.

The Kanakas (South Sea Islanders) have not been employed very extensively on the sugar plantations of New South Wales, and even in 1901, when Federal legislation in connexion with the sugar industry was passed, the number of blacks was not large. At the census of 1901 there were 239 Hindoos and 291 Pacific Islanders (Kanakas) working on the sugar plantations (Year Book). They produced about one-tenth of the total sugar in 1905.

It is, however, in **Queensland** that the chief sugar centres are situated, at Bundaberg, Mackay, and Cairns (see Fig. 53). Thus in 1905 there were 134,107 acres under cane, or six times as much as in New South Wales. The area is much the same as that under maize, and a little less than the wheat acreage, but it should be remembered that sugar is seven times as valuable a crop as wheat.

The sugar is grown chiefly on the rich soils along the valleys of the coastal rivers. The jungle is cleared away, and the cane propagated by means of short *joints*, each containing a few shoots. Thus a cluster of new canes arises which matures in about eighteen months. In the warmer districts it is possible to cut these canes many years without replanting, but in the south they need fresh plants in three or four years.

In the drier portions of the sugar area, as around Bundaberg, the success of the sugar-cane depends on irrigation. The water is obtained by tube-wells, which penetrate the water-bearing strata within about 20 feet. The water is then distributed over the plantations in ditches. The large estates have been largely subdivided in recent years, for the 'White Australia' policy favours the system of farming smaller holdings and selling the standing crop to the mill-owners.

The cane is worth about sixteen shillings per ton delivered at the mill. From four to five shillings per ton of cane is given as a Government bounty for cane grown wholly by white labour. There are now about fifty mills in Australia which handle much more cane than when there were eighty, as in 1881. In order to assist the small cane-growers the Government advanced money on mortgages of their farms, to build central co-operative sugar-mills. The cost of these mills ranged from £21,000 for a mill capable of turning out 2,000 tons of sugar during the season, to £60,000 for a 5,000 ton mill.

Referring to the map, it is apparent that the plantations are sporadic and clustered around far distant centres. There seems no reason to doubt that there is a large future before the sugar industry when the lands between these isolated areas are occupied, as similar conditions of soil and rainfall obtain at many intermediate points not yet utilized.

In 1905 the Queensland area under cane amounted to 134,107 acres; the area cut was 96,093 acres, or nearly 75 per cent., which is a considerably higher proportion than in New South Wales. The net sugar exports were valued at £1,446,695.

The isotherms for July and December, and the 30 inch isohyet, are plotted on the map. The winter isotherm of 58° determines the southern boundary (Grafton); while the summer isotherm of 83° practically limits the crop to the coast—for the reason that the *rainfall* is closely correlated with the *cooler* elevated coastal belt. In this belt also occurs the only well-watered, rich soil country, since the highlands are much too rugged for sugar plantation, while on the more fertile western slopes the rainfall rapidly diminishes.

The question of the employment of coloured labour in this industry is not within the scope of this paper. A *résumé* of the legislation on the matter is given in the Commonwealth Year Book, 1908, and a general account of the whole industry in the Year Book of Queensland from which many of the above facts are taken.

With regard to future extension there is obviously much land in northern territory and round the Gulf of Carpentaria which is suitable for the growth of cane. Cuba, which ranks fourth as a producer of cane-sugar, has a similar rainfall (50″–75″) and temperature (winter 75°, summer 85°). Nearer home is Java, where seven millions sterling are obtained yearly in this industry. Until the economically unsound policy of a White Australia be amended, there will be a tropical area equal in extent to Java and Cuba lying idle, which might be directly supporting a million of the world's humbler peoples and indirectly thousands of the white race through the manufactures arising therefrom.

The opposite point of view has been frankly stated by Bruce Smith in his book *The Commonwealth of Australia.* He says, 'Australians keep out coloured labour for political and not for economic reasons. They intend at all costs to preserve the purity of the white race. Australians have already more work than they can do in the more temperate portions of the country . . . [and] . . . are quite content that the development of tropical productions should be delayed' (p 280).

CHAPTER XXI

AUSTRALIAN FISHERIES

ALTHOUGH not very largely developed in Australia at the present time, yet several branches of this industry possess a special interest. Each of the States is endeavouring to promote the capture of *edible fish* in their coastal waters; but in the tropical seas the chief attention is paid to pearl-shell, tortoise-shell, and bêche-de-mer, which, from the zoological point of view, are not fish at all.

Referring to a map of Eastern Australia, it will be seen that there is a rugged coast-line and a highland belt parallel to, and at no great distance from it. Along the northern portion is the unique area of coral known as the Great Barrier Reef. We have along the east coast a succession of sheltered harbours, many being drowned river valleys, as at Sydney. Farther north, among the reefs of the Great Barrier, is a shallow warm-water area very suitable for the breeding of fish of valuable qualities, as well as of turtle, pearl-shell, and bêche-de-mer or trepang.

The opinion has been expressed that this environment singularly well fitted for fish-life—both drowned harbours and huge extent of shallow coral sea—is the result [1] of a common earth movement, perhaps linked with the formation of the central lowlands of Australia.

While the Western Plain country (from the Riverina to the Gulf of Carpentaria) was being slowly elevated, thus raising the pliocene and other late tertiary formations hundreds of feet above sea level—and incidentally altering the drainage system of Lake Eyre and the McDonnell

[1] Hedley and Taylor, *Coral Reefs*, Aus. Assoc., Adelaide, 1907.

Ranges (p. 116)—in a corresponding zone to the east the country was being submerged. As far as the waters were warm enough (i. e. to 28° S. latitude) the coral polyps built their colonies of lime; not raising a huge *barrier* above the waves, as many imagine, but forming a series of individual reefs each separated by a mile or two of shallow water, which are perched on the huge bulk of coral *rock*, and in many cases only appear at low tide. If one imagined the level of the sea to fall several thousand feet; looking from the Pacific, one would see a huge scarp (rising 3,000 feet in about a mile) capped by a low castellated *rampart*, which alone would be occupied by living coral colonies.

It is among these isolated reefs scattered over the surface of the 'shelf'—largely composed of submerged coral rock, partly no doubt formed by the continental shelf—that the **trepang** (bêche-de-mer) fisheries occur. This animal is largely exported to China, but is often used for soup on the Queensland coast. It is neither a fish nor a slug, as it is indifferently called by the fishers, but is an echinoderm, and therefore allied to the star-fishes. As one wades through the tepid waters of the reefs, it is difficult to avoid treading on numerous black or brownish animals —exactly resembling in size and shape a stout large cucumber—which crawl sluggishly over the coral-reef sand. These are the sea-slugs, trepangs, bêche-de-mer, teat-fish, or sea-cucumber, as they are indifferently called. Only certain genera are edible. They have no means of defence, and are obtained in thousands by the blacks. The 'fish' are boiled for a short time and then gutted. After drying they are smoked in a smoking-hut for twenty-four hours. During these operations they shrink to one-third their original bulk and become hard and leathery.

'China represents the market to which, with the exception of a few hundredweights, all the Australian bêche-de-mer

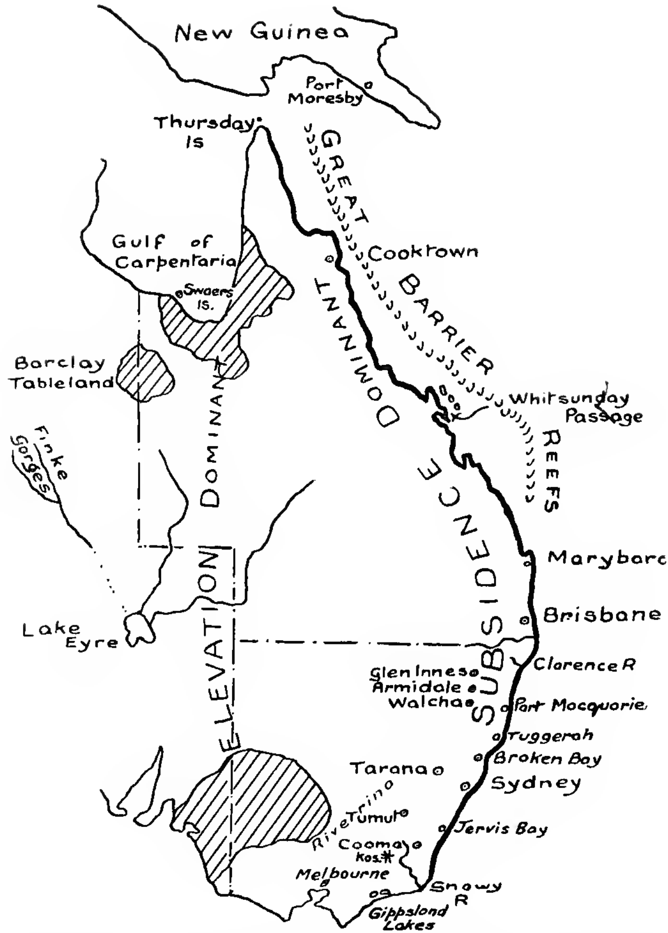


FIG. 54. Sketch-map showing the Areas dominated by Tertiary Uplift and Subsidence respectively. (Elevated sediments of late tertiary age are hatched.)

is consigned, in which market that shipped from Cooktown, and known as "Barrier fish", enjoys a higher reputation and realizes better prices than the article derived from any other locality on the face of the globe. As much as £160 per ton has been occasionally realized.'[1] In 1889 about 100 craft were engaged in the industry and realized £23,000. One ton of cured 'fish' is a good month's take for a party of twenty men and four boats. As may be imagined, this uninviting product needs much preparation before consumption; and if the writer may be allowed to express a personal opinion, the result hardly compensates for the labour involved!

The pearl industry of Queensland is confined to the tropical area, and is essentially associated with the Great Barrier Reefs. The head-quarters are on Thursday Island, Torres Strait, 30 miles west of Cape York, and from this centre shelling expeditions are made along the mainland coast-line to the northern limits of the Great Barrier and throughout Torres Strait northward to New Guinea. In the Gulf of Carpentaria also, Saville Kent was able to show the presence of the pearl oyster as far south as Sweer's Island.

The average depth of water from which the greater quantity of mother-of-pearl shell is at present collected is seven or eight fathoms (45 feet). Twenty fathoms represents about the greatest depth from which the shell is profitably fished, although few divers can stand the strain of prolonged work under that pressure. The boats employed are of 100 tons burden, there being about 100 in number, while the hands engaged may be computed at 1,000. Saville Kent (whose work on the Barrier Reefs should be consulted) states that one month's work for

[1] Saville Kent, *The Great Barrier Reef*, 1893 (fine illustrations).

a boat would result in a load of 600 pairs of shell, averaging 3 lb. a pair, and representing but little short of a ton in weight.

It is the mother-of-pearl *shell* that is primarily fished for in Torres Straits, the pearls being mostly appropriated by the hired diver and the boats' crews. Not one pearl shell in several thousand produces a large pearl, yet they constitute a valuable asset, and may even be of more value than the mother-of-pearl. Thus in 1904 at Shark Bay (in West Australia) 71 tons 16 cwt. of small shell, valued at £566, yielded approximately £2,000 worth of pearls. But this smaller West Australian variety has more numerous pearls and they are of better quality, though the shell is less valuable than the *Margaritifera meleagrina* of the Queensland coast. Some very interesting details of the habits and varieties of the pearl oyster are given by Saville Kent. He was able to transport the animals alive for considerable distances, and made some experiments on the artificial production of true pearls. Some thus obtained possessed 'a substantial intrinsic value, but . . . it has been deemed scarcely fair to speculating schemers to tantalize their minds with hazy glimpses of a royal road to the rapid accumulation of untold wealth'. So we are left in the dark as to how he produced the large 'bouton' pearl figured in Plate 38!

The average annual value of Queensland pearl-shell for the years 1884–8 was £69,000, but since then it has been decreasing in quantity and value.

In West Australia the trade centres around Broome, and to a less degree at Cossack and Onslow (see Fig. 27). In 1904, shell worth £124,000 was exported, occupying 461 boats and nearly 3,000 persons, chiefly Asiatics. Shark Bay (somewhat farther south) is the habitat of a small variety of shell, as mentioned previously, for which there is little demand, but it is interesting to learn that the experiments of transplanting the large shell from the north-west have been a marked success, and the young shells are growing vigorously.

The coasts of New South Wales are too far from the equator for any of the preceding tropical 'fisheries' to exist. Nor have we in this State representatives of the huge 'banks', which have led to the development of the Newfoundland and North Sea Fisheries of the Northern Hemisphere. During the five years 1900–4 frozen and preserved fish to the value of £782,000 were imported into New South Wales, which is considerably more than the value of what was caught locally (estimated at £500,000). But there are valuable assets—as has been abundantly shown in various departmental reports, and especially by the trawling investigations of the *Thetis*.

Mr. Frank Farnell, who conducted the *Thetis* expedition, writes: 'Fish were caught during night and day, of the best quality and in quantities that I have no hesitation in saying would form a payable basis on which to start commercial operations. Over ninety different species were captured, including John Dory, schnapper, sole, flounder, skate, and flathead. . . . Great Britain employs over 200,000 people and 25,000 vessels in this industry which gathers an annual harvest averaging millions of pounds!'

The coastal subsidence mentioned earlier in the chapter, has given rise to many fine harbours and land-locked bays, such as Port Stephens, Lake Macquarie, Lake Illawarra, Tuggerah Lakes, Broken Bay, Jervis Bay, Port Macquarie and Clarence River, near which fish in almost inexhaustible quantities are obtainable at all seasons of the year (see sketch-map, Fig. 54).

An interesting account of the Food Fishes is given by

J. Douglas Ogilby, from which the following is derived.[1] At certain seasons our seas teem with herrings of various species, which migrate northwards during the latter six months of the year. The pilchard (*Clupea sagax*) is the most valuable, and may later enter into no mean rivalry with its more famous northern relative. The sardine of commerce is none other than the young of the European pilchard, and a large import trade of tinned sardines is carried on in all the States. Among the half-beaks, the garfishes (*Hemirhampus*) are delicious fish, and are taken in quantities by special small-mesh nets. None of the fishes frequenting our shores are of such commercial importance as the sea-mullet (*Mugil dobula*). During the latter part of summer enormous shoals move northwards to their spawning-grounds; portions break off at different periods to arrive at their special breeding-haunts. Thus in the southern bays this commences in March, but the season grows later as we proceed north, until in the Clarence district June may find the shoals engaged upon the spawning-beds. For eighteen months the young mullet remain in the estuaries where they furnish the pick of the fish consumed. Then they gradually work out to sea.

The mackerel family is well represented by *Scomber australasicus*, but their shoals arrive at irregular periods, and the flesh decomposes with such rapidity that grea care has to be exercised in selecting individuals for the table. One of the most important families is that of the sea-breams, of which one member, the schnapper (*Pagrosomus auratus*) is, without doubt. the best known and most prized of all Australian fishes. In New South Wales the supply of schnappers is almost entirely due to the line fishermen, who seek them on well-known reefs at moderate depths, and off rocky points and 'bomboras'. They cure

[1] Ogilby, 'Fish Industry,' *New South Wales, the Mother Colony*, 1896.

well, and grow to very large size, the younger individuals being known as 'red bream', 'squire', &c.

Of freshwater fish, the most important is the Murray cod (*Oligorus macquariensis*), which sometimes reaches 100 lb. weight. It is found in most of the western rivers of New South Wales. The Australian perch (*Percalates colonorum*) thrives in estuaries along the coasts of New South Wales, Victoria, and Tasmania, and is said to give good sport to anglers.

Lastly, the trout has been successfully acclimatized in many of the streams in New South Wales and elsewhere. Especially is this the case in the district around Mount Kosciusko. Over 140 streams have been stocked with fry, yearling or two-year old trout by the Fisheries authorities. The chief centres are Cooma for the Snowy River, Tumut for the Yarrangobilly River (both in the south); Tarana on the western line for Fish River, &c.; in the north, Walcha for the head waters of the Namoi (Macdonald, &c.); while many of the streams near Armidale and Glen Innes afford good sport (see map, Fig. 54). The same energy in stocking the rivers is shown by several of the other States.

CHAPTER XXII

THE COPRA INDUSTRY

Some explanation may be deemed necessary for the inclusion of this industry in an account of Australia. In brief, copra is the dried kernel of the ripe coco-nut, and constitutes the staple article of commerce of the South Pacific. As, however, a very large proportion of it is brought to Sydney and converted into oil and oil-cake at that city, a short description of this trade will not be out of place.

The writer recently had the *real* pleasure of a cruise among the coral islands of the Pacific, and the *doubtful* pleasure of breathing an atmosphere of copra for some weeks! At every port, manufactured goods, consisting largely of cotton, kerosene, biscuits, and hardware were put on shore, while the universal return cargo consisted of large sacks of copra, each weighing some 140 lb. Coco-nuts do not grow wild, and probably rarely spring from nuts which may be cast ashore by the sea, as one was taught in the earlier geographies. Nevertheless, a sprouting nut needs only to be planted in the moist soil of these islands and a tree will result. The best trees grow in Samoa, and seed-nuts are therefore exported from that island.

Each householder has his group of trees, some in the village, some in the 'bush'. His taxes are paid in kind, usually in copra. Under the speading star of leaves crowning the coco-nut tree are several generations of nuts; small, immature units the size of walnuts, full-size specimens with delicate creamy kernels, older nuts filled with an invigorating milk, resembling lemonade, and later still the outer skin becomes brownish instead of green, and the kernel is ready for conversion into copra. The fruit consists of a large egg-shaped mass of husk enclosed in a tough skin, and within these, occupying perhaps half the bulk, and rather to one end, lies the familiar coco-nut of the fruiterer. In Samoa the nuts are stored by tying two together by their husk fibres, and clustering such pairs

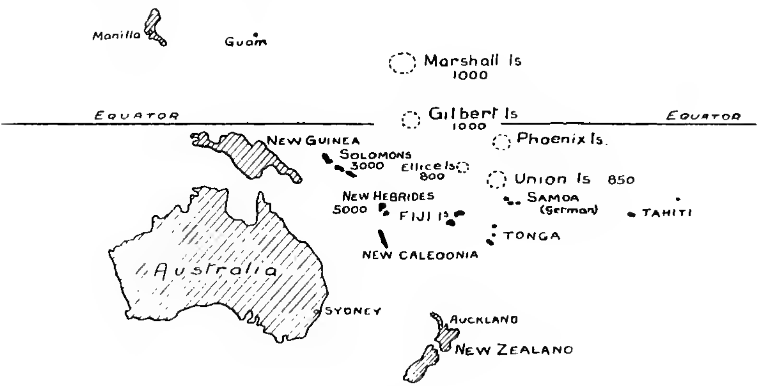


Fig. 55. Copra Industry in the Pacific. Figures roughly indicate the tons yearly exported to Sydney.

around a stout post. Thus they keep dry and do not rot or sprout. The whole fruit is later split in halves and spread out for several days to dry. In rainy regions, such as in the Solomons, they may be smoke-dried. Then the kernel is chipped out of the hard shell with a knife, and the crude product bagged and stored till the next steamer comes along. Ten trees give about 2,000 nuts (two crops) in the year, yielding about a ton of copra.

In Samoa the Germans have probably the largest plantation in the world, worked by 'boys' imported from the Solomon Islands. The natives of Tonga, Samoa, and Fiji, though physically a splendid race, are very indolent and self-satisfied, and will not readily work for the white trader.

I owe to Mr. Chandler, who is intimately connected with the Sydney trade, the figures attached to the groups in the map. Many of the islands are mere rings of coral (atolls), and the cargo is sent off in large flat-bottomed surf-boats, which actually have to bump their way over the reefs on the larger waves. Such is the case in the Union group and many of the Ellice, Gilbert, and Marshall islands. The Germans control the crop in the Marshalls and Samoan islands and, perhaps naturally, do not encourage British trade. The English companies are, however, making large plantations themselves in many of the islands, notably in the New Hebrides, Solomons, and Phoenix groups.

The price for crude copra has risen considerably from £12 per ton in 1900 to over £20 per ton in 1906. On arrival in Sydney the copra is grated into shreds and the oil squeezed out. Floating soaps—such as the well-known Swan soap—consist almost wholly of this oil. The heavier soaps have a certain amount of tallow, palm oil, cotton-seed oil, &c., mixed with the coco-nut oil. The residue, containing ten per cent. of the oil, is a valuable fattening food for cattle, and constitutes the well-known oil-cake.

SECTION V. TRANSPORT

CHAPTER XXIII

THE RAILWAYS OF AUSTRALIA

I HAVE dealt rather fully with this section because the distribution of population and industries is so closely bound up with the evolution of the railways.

These differ from most important railway systems outside continental Europe, in that they are State-owned. Only a few of the railways, usually connected with mining centres, belong to private corporations. In a recent Government publication the mileage is given as nearly 17,000, the construction of which cost £134,000,000, and last year earned 3¼ per cent. after paying all expenses. The railways are apportioned as follows:—

New South Wales . . .	3,600 miles approximately.
Queensland	3,300 ,, ,,
Victoria	3,400 ,, ,,
South Australia and Northern Territory	2,000 ,, ,,
West Australia	2,000 (and 627 private).
Tasmania	618 (including private).

The longest continuous journey (3,303 miles) by rail extends from *Oodnadatta*, north-west of Lake Eyre in South Australia, to *Longreach* in Central Queensland (see Fig. 56). The latter town is situated on the upper waters of the Barcoo River, which flows into Lake Eyre; so that the complete circuit could be made by returning via the stock routes which connect Central Queensland and the Lake Eyre Basin (see the section on the Artesian Basin and Stock Routes).

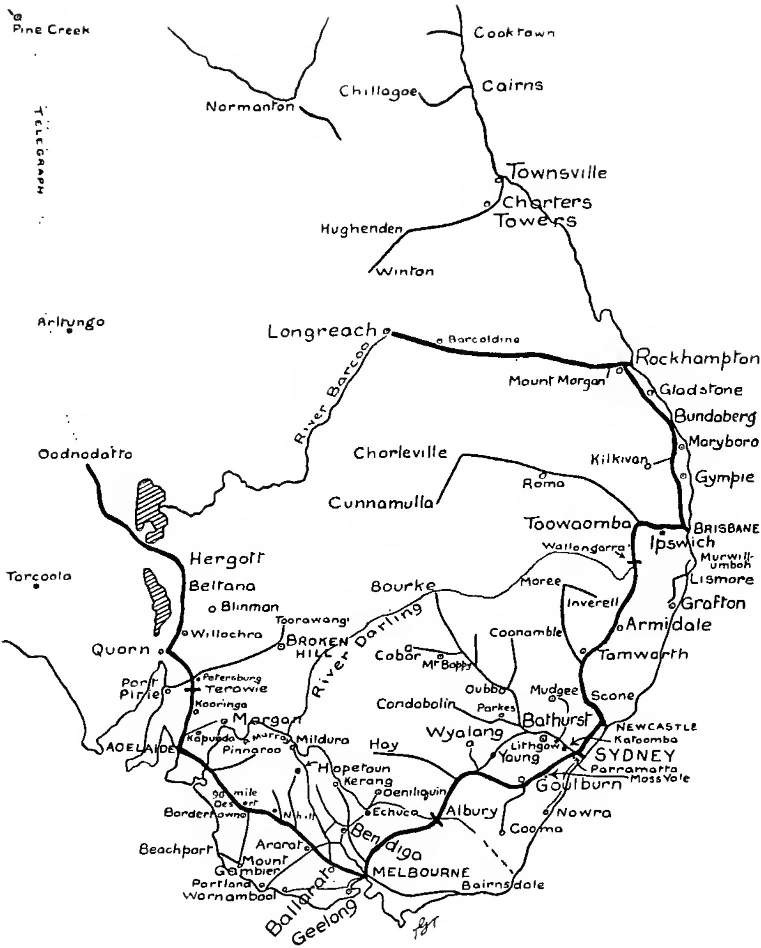


Fig. 56. Railways of Eastern Australia.

It will be profitable, perhaps, to imagine oneself travelling over this route, which circumscribes the most important section of Australia [1] (see Fig. 56).

Oodnadatta is 688 miles north of Adelaide, and is at present the northern terminus of the southern railways. From here a 'Land Grant Railway' to Pine Creek and Port Darwin is proposed, a length of 1,063 miles. 'It is claimed that it will be practicable for passengers and mails to reach Port Darwin by the Siberian Railway route in fourteen days from London, and (by this projected railway) Adelaide in seventeen days. . . . The country presents no great engineering difficulties. For the most part it is one vast plain, with here or there a sand ridge or a watercourse.' [2] On the other hand, as the whole of the country traversed is in rainless or tropical country, it does not seem a very profitable scheme for 'White Australia' to undertake at present. The population (D. J. Gordon) of the Northern Territory consists of some 880 Europeans, 2,500 Chinese and others, totalling 4,000. Quoting Mr. Playford (Parliamentary Paper 97, 1892), 'The Territory must have cheap labour if tropical products are to be grown and sold with profit in the markets of the world. European labour is not cheap, therefore if Europeans could stand the climate, tropical products could not be produced at a profit by them. Southern Australia has declared for a White Australia, and until there is some modification of that policy Northern Australia must continue to remain an unoccupied paradise of vegetable vitality and tropical luxuriance.' [2]

Oodnadatta is connected with the southern settlements by a narrow gauge (3′ 6″) railway as far south as Terowie. The first section extends to Hergott Springs, and trains

[1] The writer journeyed from Beltana (near Lake Torrens, South Australia) to Brisbane—the greater part of the above route—in 1906.
[2] From *The Central State*, by D. J. Gordon, 1903.

run over it but once a fortnight. The country is occupied by sheep stations, in which large areas to a certain extent compensate for small rainfall. Some mining is carried on in the interior; at one time the gold-field of Arltunga (see Fig. 28) seemed very promising, but expectations were not realized. The maintenance of the Overland Telegraph, and the supply of the sheep stations in the comparatively favourable hilly areas in the centre of the continent, account for most of the traffic. From Hergott the main stock route to Queensland starts.[1]

South of Hergott, the service consists of several trains a week, though the passenger trains do not run after nightfall. The writer visited this area during the summer 1905–6, when it certainly did not show its most favourable aspect. Many of the stations had been abandoned, owing to drought and rabbits, and the chief enterprise centred around small copper 'shows', such as the Ajax (Beltana) and Sliding Rock. After a period of rest the 'blue-bush' (an ally of the salt-bush) would revive again, affording good feed, but the absence of permanent pasture and water, and a rainfall less than 10 inches, would seem to discourage closer settlement.

The writer has a vivid memory of drinking water pumped from copper mines, from alkaline sub-artesian channels, or from aged water-holes. After a heavy thunder-storm, the fresh rain-water was procured with much difficulty from a small shower-bath,—the Beltana residents preferring not to endanger their internal economy by too drastic a change in the water supply!

Near Parachilna the Flinders Range on the east assumes a definite direction and elevation, and some of the settlements have a correspondingly better rainfall (Blinman, 13 ins.). But the low-lying swampy shores of Lake Torrens

[1] This area is well described in Gregory's *Dead Heart of Australia*.

—whose waters, I was informed, had never been traversed by a boat—have a rainfall of only 8 inches. At Willochra the train was filled with a fine sand, so dense one could hardly see across the car. This was due to an attempt to grow wheat, which broke up the natural surface. Ensuing desiccation converted the soil into a drifting sand of a peculiarly portable character. Yet in exceptional seasons wheat can be profitably grown as far north as this. At Quorn we have left the arid regions, and here all the passengers detrain for the night. Farther south and considerably to the east is Petersburg, an important junction, where the silver-lead from Broken Hill—'the greatest mine on earth,' as it has been called—crosses to reach Port Pirie on the Gulf. At Terowie the broad gauge (5 feet 3 inches) necessitates a change of cars,—which can now run through Adelaide and Melbourne uninterruptedly to Albury. Kooringa is close to Burra, which in 1860 was one of the most famous copper mines in the world, but since 1877 little ore has been raised.

The railway passes through the wheat and sheep belt, being joined at Roseworthy by the long branch line from Morgan on the Murray. Near Roseworthy are Tanunda (a great wine district) and Kapunda, the first copper mine worked in South Australia. A run of 50 miles brings us to Adelaide, a remarkably well-designed and handsome city, situated on the plains at the foot of Mount Lofty (2,400 feet) about 5 miles from the coast. It is characterized by its wide streets and abundant parks, and enjoys 'about the lowest death rate in the world'.

The Interstate Railway crosses the Mount Lofty hills by nine tunnels and a viaduct over 100 feet high. Here are situated the beautiful residences and gardens of the Adelaide merchants. On the western slopes around Reynella and Morphettvale are some of the most important vineyards in Australia. Some 40 miles east the Murray is crossed at Murray Bridge. The old river swamps are being drained and embanked, and large quantities of vegetables and maize are grown in the extremely deep black soil. After following the Murray for 12 miles Tailem Bend is reached. The branch line from this point to Pinnaroo (80 miles) will open up a huge agricultural district (16–17 inches rainfall) where wheat should be grown successfully. Between Tailem Bend and Serviceton (on the border of Victoria) the train crosses the Ninety Mile desert, 'an immense plain of 14,000,000 acres of worthless calcareous hungry sand, 3 feet deep, overlying a heavy clay, and clothed by a miscellaneous growth of stunted trees and scrubby brushwood, which furnish abundant evidence to a practical observer of the absolute worthlessness of the soil'. (R. Wallace, F.R.S.E., *Rural Economy*, 1891.)

An interesting explanation is advanced by Mr. Howchin, of the Adelaide University, of the *surface* limestones which are so characteristic of the drier portions of Australia. These have a comparatively small depth, but cover square miles of country, following the outcrop of the older rocks below. They furnish a rather poor soil which may be absolutely barren, as in parts of the Ninety Mile Desert and Mallee districts. The evaporation due to the heat of the sun is excessive in these regions, and removes all the water in the top layers of the soil. Thereupon the underground waters rise to take its place. These are often charged with small quantities of *lime* and other alkalies dissolved from felspars in the granites, or from other limestones, &c. On reaching the surface, the lime is deposited as this water also passes off into atmosphere. The lime-waters will also dissolve silica (sand grains), and so in some regions hard quartzite crusts are formed in the same way.

As Professor Gregory puts it in an independent article[1]:—'The geographical character of the north-western plains of Victoria and the nature of the vegetation that grows on them are therefore dependent on the distribution of the underground waters, and on the nature of the materials that those waters dissolve during their ascent to the hot surface of the perspiring earth.'

From Bordertown an important branch line runs south to the isolated district of Mount Gambier. This is a volcanic district famed for its crater lakes and fertile soils. It is blessed with a rainfall ranging from 25 to 32 inches, and the summer temperature is the lowest in the State, so that it is much visited as a holiday resort. It is said to be the 'ideal home of the dairyman', and all the English fruits, such as apples, pears, cherries, and berry fruits do well. Potatoes and onions are the chief products, however.

Much of the country in North-West Victoria is covered with 'Mallee' scrub—thickly clustered eucalypts about 15 feet high with characteristically swollen root stocks. This is pulled down by chains dragged by oxen, or by some similar method, and yields fair crops of wheat. Near Nhill and Dimboola are extensive water conservation works, as mentioned in the section on Irrigation.

The railway gradually rises and crosses the complicated series of highlands, which cannot (in Professor Gregory's opinion) be justly termed the Great Dividing *Range*—since they are composed of such diverse elements from a geographical point of view. At Ballarat we reach the southern portion of the best known Australian gold-field. Here are Dunolly, Poseidon, Bendigo, Maryborough, and many other townships, where huge nuggets were found in the heavy clay soil within a few feet of the surface. Now the mining is chiefly concerned with reefs, and the country

[1] Gregory, *Geography of Victoria*, p. 95.

is largely occupied by thriving farms. Ballarat is an extremely prosperous town, and its citizens would appear to have a keener sense of municipal responsibility in the matter of embellishing their town than is usual in Australia. Fine public gardens, parks, and statues, and the large artificial Lake Wendouree greatly enhance the natural attractions of Ballarat. From here the line descends the Bacchus Marsh scarp to Melbourne.

Professor Gregory, in his *Geography of Victoria*, gives an interesting *résumé* of the growth of Victorian railways. This—the smallest mainland State—has as many miles of railways as any of its larger neighbours, and their distribution is closely related to industrial development. Thus 1854–60 is the period of *suburban* lines around Melbourne, including one to the port of Geelong. Some few years later (1862) Ballarat, Bendigo, and other great *mining* centres were being connected to the metropolis. In 1873 the Victorian section to *Sydney* was completed—the Adelaide section, being less important, was only finished in 1887. Lines tapping the southern *agricultural* districts of Sale, Portland, and Colac, were completed in the seventies. From 1880–90 the north-west plains (Donald, Boort, and Kerang) were linked up, and the direct route to *Ballarat* over the Bacchus Marsh scarp was opened; the earlier railway was via Geelong. From 1890–1900 the chief railway construction took place in the Mallee plains in the north-west, where five parallel lines extend to Rainbow, Hopetown, Woomelang (and later to Mildura), Saltlake, and Ultima.

From Melbourne the main line runs north-east, no important branches leaving on the east where the rugged mountains of Northern Gippsland present exceptional difficulties to the engineer. In the basin of the Ovens River are many gold mines where the 'deep leads'—alluvial covered by basalt—give employment to a large number of miners at Chiltern and Rutherglen. Dredges also do well as at Yackandandah, where an extremely small gold content is profitably handled.

At Albury the gauge changes from 5 feet 3 inches to the standard English width of 4 feet 8½ inches, so that the Victorian cars are left here for those of New South Wales. Albury is on the Murray, and is the largest town in the Riverina, which lies north and west of it for the most part. Mining (at Corowa), vineyards, wheat and sheep are all important industries in the neighbourhood. On the east of the line are the rugged slopes which culminate in Mount Kosciusko (7,340 feet), and these are not traversed by railways. Wagga—with similar industries to Albury—is situated where the railway crosses the Murrumbidgee. From Junee a branch line to Hay passes through country which will be irrigated by the Barren Jack Reservoir. At Cootamundra we are in the foothills of the Eastern Cordillera, and here a branch runs to Wyalong, one of the most satisfactory gold-fields in Australia. At Murrumburrah (Harden) the only important loop in the New South Wales railway system occurs. Here it is possible to proceed north to Blayney and thence to Sydney by the Great Western line, passing through Young and Cowra—both rich mining, agricultural, and pastoral districts on the western slopes of the State. On the southern route we proceed eastward to Yass, near which is the site of the federal capital, and cross the Divide between the Murray system and the coastal rivers near Goulburn.

The authorities in New South Wales are wisely rejecting the term the Great Dividing *Range*. The terms, Northern, Central, and Southern Highlands or Plateaus of New South Wales, may be conveniently used in its place. The term tableland which has been suppressed is applicable only to part of these highlands. These three divisions are separated from each other by two broad relatively depressed areas, to which the name *Geocol* has been applied.[1] The Southern line, with which we are at present concerned, traverses the Lake George geocol and soon arrives at Goulburn, a town of 10,000 inhabitants, engaged chiefly in agricultural pursuits. Here an important branch line runs south along the tableland to Cooma, the chief town of the Monaro Plateau, 2,657 feet above sea level, and of growing importance as a tourist resort, and the entry to the Snowy Mountains and Kosciusko areas.

The next important town on the main line is Moss Vale, which rivals the Blue Mountain district as a holiday resort in summer. It has large areas of rich soil, due to the weathering of volcanic lavas, where splendid crops are grown. The train rapidly descends to the plains around Camden—the earliest pastoral settlement in Australia—and thence over the undulating country characteristic of the triassic shales to Sydney.

Sydney, like its friendly rival Melbourne, has a population of over 500,000. (On December 31, 1906, the metropolis, comprising Sydney and the forty municipalities of the suburbs, had a population of 538,800.) The life and industries in the two cities are much the same, the River Yarra and Hobson's Bay being, however, a poor substitute for Port Jackson. The terminus of the lines at Sydney is also more imposing and convenient than the two stations at Melbourne. The latter are to be replaced in the near future by up-to-date buildings. Finally, the main streets of Melbourne are undoubtedly better fitted for the needs of a great city, than the comparatively narrow and winding thoroughfares which carry Sydney's main road traffic. 'In the old charts and views, the outline of what is now George Street, and the main artery of the city, may be traced as a winding

[1] *Proceedings of the Linnean Society*, *N.S.W.*, vol. 31, p. 517.

bullock-track, starting from the vicinity of Dawes Point and pursuing its sinuous way round obstacles and past certain fixed points without any regard whatever to mathematical directness.'[1]

All the railways of New South Wales converge on Sydney, and the history of their growth is interesting. The first railway from Sydney to Parramatta (15 miles) was hardly well started in 1850, when all the employees ran off to the gold-fields. It was completed in 1855, while the extension to Goulburn was opened in 1869. From 1880–5 the railways were extended to centres already populous and prosperous, viz. Riverina and New England and the central districts of Wellington and Dubbo; also the Murray was crossed into Victoria. From 1885 the extensions on the main lines have for the most part been through pastoral country. Mention must be made of the huge Hawkesbury Bridge, with the deepest piers in the world, which was completed in 1889, and placed Sydney in communication with Newcastle and Queensland, though the section north of Newcastle to Tamworth had been finished ten years. In 1893 the South Coast line was completed to its present terminus Nowra. The later lines are in the west and northern districts, such as those to Condobolin, Coonamble, and Inverell. The only important isolated system in the State is in the extreme north-east, in the sugar-growing districts. It links Grafton, Casino, Lismore, and Murwillumbah.

Before continuing our inter-State journey to Queensland, we may glance briefly at the Great Western system. This is a continuation of the original Sydney—Parramatta line, and was carried without difficulty to Penrith at the foot of the Blue Mountains. These rise abruptly to heights of 3,000 feet, and presented grave difficulties to the engineers.

[1] J. M. Taylor, *Geography of New South Wales*, p. 114.

They were surmounted by zigzags and tunnels in 1876, necessitating gradients as steep as 1 in 30. Comparatively recently extensive deviations have improved these grades considerably. The Western line has led to the growth of an important chain of summer resorts some 70 miles from Sydney, of which Katoomba and Mount Victoria are the most important. They are situated on a comparatively narrow ridge bounded by the precipitous slopes of the famous Blue Mountain Valleys. No inconsiderable proportion of the passengers detrain here to visit the Jenolan Caves, about 35 miles south-west from Mount Victoria, which are perhaps the most picturesque of all stalactite caverns. Soon the line drops down into the Lithgow Valley, an important industrial district. Bathurst is on the head waters of the Macquarie, and its plains are devoted chiefly to wheat-growing and sheep. Thence the railway runs to Blayney (and Harden) and Orange—the famous gold-fields of Sofala, Hill End, Hargraves, and Ophir, lying to the north.

A branch line to Condobolin passes through mining districts at Forbes and Parkes, and much wheat is grown, though the rainfall is rather uncertain and the crops do not always succeed. Dubbo, on the main line, is situated on the edge of the western slopes, and beyond that the line runs to Bourke across a plain so level that every slight elevation is called a hill. The branch line from Nyngan to Cobar is of much greater importance than the main line to Bourke, for a great proportion of the copper and gold in the State is obtained in the mines in and around Cobar, such as Nymagee and Mount Boppy. A line to Coonamble from Dubbo taps an important pastoral area, while an important line runs from near Lithgow to Mudgee, passing extensive mines of kerosene shale near Capertee.

The Northern Railway, after leaving the suburbs of

Sydney, passes through the barren, rugged gorges of the Hawkesbury River, which has given its name to the sandstone of which the rocks are formed. After the Hawkesbury River is crossed, the coal measures are soon entered and the country becomes much more fertile. The chief occupation is naturally coal-mining, and the increase in population during the last few years has been very great. Newcastle (with its suburbs) has now 61,400 inhabitants.

From Newcastle the Northern line goes north-west up the fertile Hunter River flats, where large quantities of maize and lucerne are grown, though floods are an objectionable feature in the valley. North of Scone is Mount Wingen, a 'burning mountain', in its truest sense, since here a coal seam has been burning for many years, whereas volcanoes are not, strictly speaking, burning mountains. At Murrurundi the railway crosses the Divide and reaches the fertile valleys of Quirindi and Tamworth, chiefly devoted to cereals and sheep, though mining is carried on in the neighbourhood. A long branch line to Narrabri and Moree traverses the northern wheat belt, and an extension to Inverell reaches the chief tin and gem-producing districts in the State.

The railway gradually rises from Tamworth and practically runs along the summit of the northern plateau, which consists chiefly of granite. Armidale is the chief town, and squatting and agriculture the chief industries. Extremely rugged country lies to the east of Armidale, and picturesque waterfalls and cañons are numerous. Few important towns are passed before the Queensland border is reached just beyond Tenterfield.

At Wallangarra-Jennings the uniform Queensland gauge (3′ 6″) necessitates a change of car, being the third (Terowie, Albury, Jennings) and last on the 3,000 miles journey to Longreach.

Brisbane, the capital of Queensland, is situated much nearer her border than is the case with the other State capitals. Hence a comparatively short journey from New South Wales through Warwick, Toowoomba, and Ipswich brings us to Brisbane. Toowoomba is the chief town of the Darling Downs, an elevated country, chiefly basalt, which has a good rainfall, and is one of the most flourishing agricultural districts in Australia. Ipswich is the outlet of an important coal-mining area.

Brisbane is situated on a pretty river of the same name, and has a population of 126,000. It ranks with Adelaide, therefore, rather than with Sydney or Melbourne. In Queensland, however, the population is less centralized than in any of the other colonies. It has a long sea-board with good harbours, but a somewhat rugged coast, which leads to railways radiating from the ports rather than a coastal system linking the towns to the capital. Thus the line, extending from Rockhampton 400 miles inland, was completed long before the necessary connexion from Rockhampton to Gladstone, a matter of only 70 miles.

The North Coast Railway keeps near the coast, and passes the well-known Glass House Mountains, whose rounded domes were so named by Cook. It goes through Gympie, an important gold-mining centre, and follows down the Mary River, the haunt of the extraordinary lung-fish *Ceratodus*. Maryborough is the centre of a sugar-cane-growing district, and has important foundries. The hinderland is rich in valuable timbers, such as *Dammara robusta* ('Queensland Kauri'), while several mining-fields, such as Kilkivan, are connected by branch lines. The next large town is Bundaberg, another very important sugar district (*vide* the section on sugar). Cattle are very largely bred in the hinderland behind Bundaberg and Gladstone. Rockhampton is situated on the tropic of capricorn, and is

380 miles north of Brisbane. It lies on the right bank of the Fitzroy River—one of the most important in Queensland—some 35 miles from the mouth. Vessels of 1,500 tons can berth alongside the wharves at Rockhampton. It has a population of 16,000, and is the terminus of the Central Line, extending 428 miles due west to Longreach. Twenty-six miles south-west of Rockhampton is the once phenomenally rich gold mine Mount Morgan—where the gold occurs in siliceous sinter, and according to one theory, was deposited by a geyser. The gold-yield has fallen considerably, but copper ores are abundant at lower levels.

Extensive preserved meat works are situated near Rockhampton, which is the natural outlet of one of the chief cattle districts of Australia. On the whole, however, the Central Railway runs through sheep country—there being (in 1905) 2,800,000 sheep within a radius of 100 miles of Barcaldine, certainly the densest sheep area in Queensland.

Longreach is the terminus of the long journey which started at Oodnadatta, and which may be tabulated as follows:—

	Miles.	*Total Miles.*
SOUTH AUSTRALIA		
Oodnadatta to Adelaide	688	688
Adelaide to Serviceton	193	881
VICTORIA		
Serviceton to Melbourne	289	1,170
Melbourne to Albury	190	1,360
NEW SOUTH WALES		
Albury to Sydney	392	1,752
Sydney to Wallangarra	492	2,244
QUEENSLAND		
Wallangarra to Brisbane	233	2,477
Brisbane to Rockhampton	397	2,874
Rockhampton to Longreach	428	3,302

Of the remaining railways of Queensland the most important are as follows: the *Great Western Line*, 600 miles long, links the pastoral areas of Cannamulla, Charleville, and Roma with Brisbane; the *Great Northern Line*, from Townsville south-west towards Winton (368 miles), passes through the flourishing reef-mining district of Charters Towers, where 'a town of 24,000 inhabitants (including suburbs) has formed itself on the high granite country where Mosman and his mates (the original prospectors) hobbled their horses in 1872, and where in every direction the poppet-heads of famous mines can be seen above the houses. About 5,266,754 ounces of fine gold had been taken from the field up to the end of 1905' (*vide* the Year Book). It is significant that the two main termini—Longreach and Winton—are only 100 miles apart, so that it seems not improbable that Townsville will be connected with the inter-State railways across the level western plains before the coastal railways are linked from Rockhampton to Townsville. On the other hand, it must be remembered that a splendid 'inland sea' exists within the Great Barrier Reef along the Queensland coast, so that safe and rapid transit by powerful steamers connects all the ports where the railways reach the coast. From Cairns a flourishing private railway serves Chillagoe and the mining districts adjoining. It has been constructed along the Barron Gorge past the Falls where the Barron River drops 600 feet in a series of cascades. Shorter railways at Cooktown and Normanton lead some 50 miles inland, but do not compare in importance with the foregoing.

In Western Australia (see Fig. 57) the first railways were pushed inland from three widely separated ports. From Geraldton, in 1879, to the copper mines of Northampton; Freemantle to Perth (1881), and extended to Beverley in 1888; and lastly (in 1891), in the agricultural and timber district, from Bunbury to Boyanup. Next a land grant railway was built for 250 miles from Albany to Beverley by a private company in 1889. This was at first an unprofitable undertaking and was sold to the Government in 1896. Another large private line is the Midland, running for 277 miles northward. This was constructed under

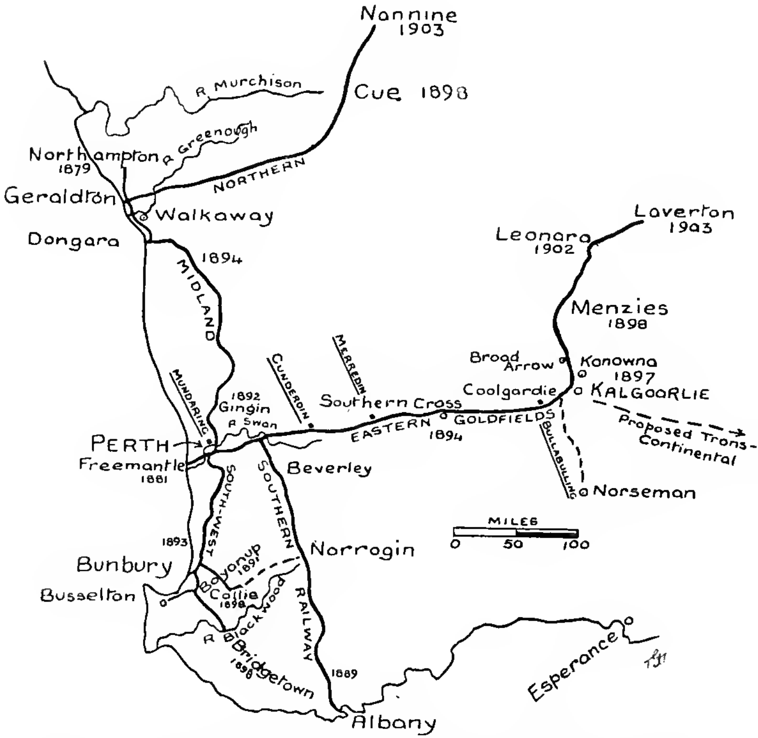


FIG. 57. Railway Development in West Australia. (Pumping stations on gold-fields' water supply are underlined.)

a concession of 12,000 acres of land for every mile of railway, and unites the Geraldton system to the Perth railways. The nineties were marked by extensive construction directly dependent on the mining industry. Thus in 1894 the line to Southern Cross was completed, and gradually extended, as the value of the gold-fields became assured, to Kalgoorlie in 1897, and Menzies in 1899. Within the last few years this line had reached Laverton, 595 miles from Freemantle. A parallel development has taken place in the Murchison gold-field further north, the railway reaching Cue in 1898, and Nannine in 1903. Two short railways of much economic importance traverse the south-west; one from Boyanup to Bridgetown, tapping the richest timber districts: and the other from Brunswick to Collie, which supplies most of the coal used on the Western Australian railways. These two lines were completed in 1898.

In concluding this section, something may be said of the proposed connexion by railway of Western Australia with the Eastern States. In the engineer's official report (1903)[1] the probable cost is put down at over $4\frac{1}{2}$ millions sterling for a line of 1,100 miles joining Kalgoorlie to the South Australian railways via Tarcoola (a mining-field, shown on Fig. 56, 569 miles north-west of Adelaide beyond Lake Gairdner). The West Australian Government have prospected for water along this route, but with only partial success. The chief benefits would be to draw West Australia and the other States of the Commonwealth into closer relationship, to afford a safe and rapid means of conveying men and arms in case of foreign attack, and to save two days in the delivery of mails. New tracts of pastoral country, which might be profitably occupied, would be opened up, and probably the living conditions of the West Australian gold-fields would be ameliorated.

The isolated position and small extent of Tasmania render its railway system of much less importance than those of the other States. The main lines (3′ 6″ gauge) have been mentioned in the preliminary section (p. 86).

[1] See the *West Australian Year Book*, 13th ed., p. 802, Perth. 1906.

One feature of interest is the presence of lines with a gauge of only 2 feet—in the mining-fields of the north-west. They are of small extent, however.

Of the gauges in use in Australia, the New South Wales lines (totalling 3,390 miles) are all 4′ 8½″; Victoria and South Australia possess 3,819 miles of 5′ 3″ gauge, while there are nearly 7,000 miles of the lighter 3′ 6″ gauge in Queensland, Southern and Western Australia. When unification takes place—as must some day occur—probably the 4′ 8½″ will be chosen, since embankments and tunnels on the 5′ 3″ lines will serve for these trains, while the carrying capacity of the 3′ 6″ railways seems somewhat inadequate for heavy traffic.

CHAPTER XXIV

INTERNAL NAVIGATION

In consequence of the general aridity of the continent, there is little possibility of canalization in Australia. In the vast central area, water is lacking not only for transport, but even for vegetation, as explained previously. However, in the south-east portion of the continent there is one large river-system which in time of average rainfall is used considerably for navigation. This is, of course, the Murray-Darling system, which forms the natural outlet for the produce of the Riverina and Western Plains of New South Wales.

An extremely interesting series of articles, published originally in the Adelaide newspapers, has been issued separately under the title 'The Nile of Australia' by Mr. D. J. Gordon [1] to which the reader is referred for greater detail than follows below. The paper on the Murray basin by R. T. McKay, referred to in the section on irrigation (p. 161), will also be found very profitable reading in this connexion.

Some figures given in the latter article are of interest. 'The Murray basin covers an area of 414,253 square miles, being almost three times the size of Japan, which has a population of 46,000,000 of people—whereas not more than 500,000 people are living within the Murray basin area.'

It must be remembered, however, that some of this area is situated within the 10 inch isohyet; while Japan is

[1] Published 1906 by W. K. Thomas of Adelaide.

favoured with an average rainfall of over 60 inches! Such facts as these are constantly overlooked by patriotic Australians in their estimates of the future prosperity of the Commonwealth.

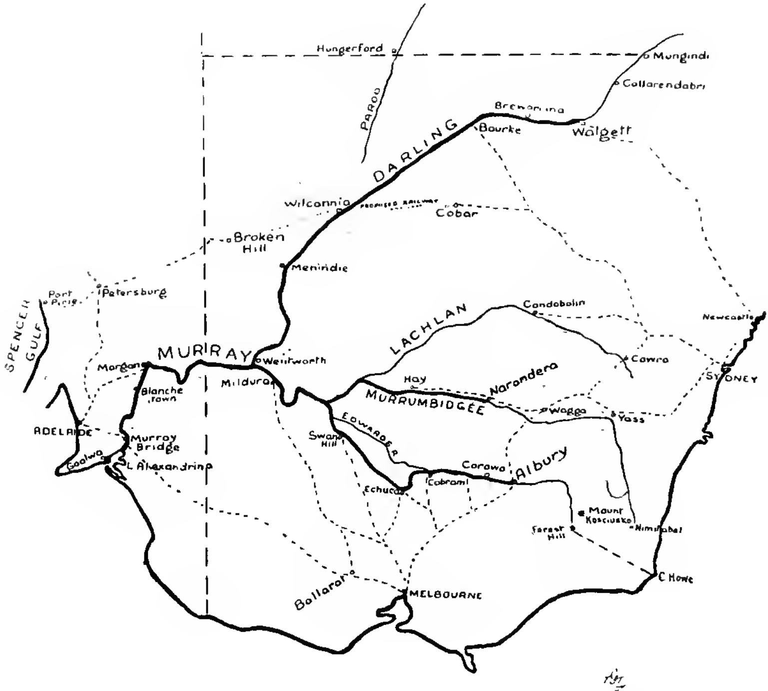


FIG. 58. Navigable Rivers of South-East Australia. (Railways to river towns also shown.)

Gordon (p. 5) describes the course of the Murray as follows:—'After beginning its long and tortuous journey to the sea in the Snowy Mountains, near to Mount Kosciusko, the Murray steers a northerly course. Before Albury is reached, the swollen waters of the main stream turn towards the setting sun, and start on their great westerly course between Victoria and New South Wales. From Albury to Wentworth, a distance of 850 miles, the fall of the Murray varies up to a maximum of 9 in. to the mile; and from Wentworth for the remaining distance of 617 miles, the fall is never greater than 3 in. in a mile. Even in flood-time the current is slow, and engineers regard this fact as an important consideration in support of a system of locks.'

Speaking of the Darling—the largest northern tributary of the Murray—Mr. Gordon writes: 'From Mungindi, in New South Wales, to Wentworth, the Darling has a length of 1,350 miles. The general fall of the river is about 3 in. to the mile, and the velocity, even in flood-time, is only about 3 miles an hour. The channel is clearly defined by banks from 30 to 40 feet high in places. In times of big floods the river overflows, and the waters cover the low-lying lands for many miles. Steamers have been navigated from 20 to 30 miles away from the channel on the flood waters. In 1870 a steamer went from the Darling, along the course of the Paroo to beyond the Queensland border, a distance of 180 miles. The spread of water was then *about* 60 *miles wide*.'

Two episodes in Australian history are of especial interest in this connexion. On February 11, 1830, Sturt and his companions reached the sea in their whaleboat, which had carried them for thirty-three days down the Murrumbidgee and Murray. Even at that early period the difficulty of navigation at the Murray mouth was recognized. He writes: 'Immediately below me was a beautiful lake (*Alexandrina*) which appeared to be a fitting reservoir for the noble stream that had led us to it [but] . . . I immediately foresaw that in all probability we should be disappointed in finding any practicable communication between lake and ocean.' Then they turned back, and after enduring great hardships on starvation rations, succeeded in reaching Sydney, 'having unlocked to the world Australia's largest river system.'

The next chapter of history relates to the first successful navigation for commercial purposes. Captain Cadell in 1851–3 spent much time preparing for a bold attempt to obtain the Government bounty of £4,000 offered 'to the first steamboat which should succeed in navigating the Murray from Goolwa to the Darling'.

We read of his reconnaissances in a canvas boat; whenever she leaked, 'we clapped the frying-pan on the fire, and after cooking our mutton chops, gave her a coat of tallow-grease, which was at all times effectual!' In 1853 the steamer *Lady Augusta* 'was pushed through the sea mouth' and reached Swan Hill (at the mouth of the Loddon) in Victoria. The first cargo comprised wool of the Murray, Darling, and Murrumbidgee rivers.

The Murray and its main tributary, the Darling, are intermittently navigable for no less a distance than 2,500 miles; but with the exception of a simple lock at Bourke, little has been done to extend the period when these streams are capable of being utilized as a channel of trade to the interior. However, New South Wales has expended a quarter of a million, and the other States lesser sums, on such river works as have been done.

Australians are not yet fully awake to the relative costs of carriage by water and rail. A well-known authority (Dr. Rose) sums up a report on Continental Canals thus: 'A comparison of the two methods of transport is altogether in favour of the waterways—a fact which seems to be much more keenly appreciated on the Continent than in the United Kingdom' (and one might add, in Australia). 'A canalship of 600 tons carries as much goods as sixty railway wagons, requires only one-thirtieth of the hauling power necessary on level railroads, is one-third cheaper in carriage per ton, and is worked at a lower rate of expenditure for men and materials. In Germany the cost of transport *per mile and ton* is stated to be less than one farthing. France has spent over £100,000,000 and is contemplating the further expenditure of £20,000,000.'

The Royal Commission which discussed the problem in Australia has made some definite rulings and elicited much information on the important question. I have made free use of their report in the following paragraphs.

As the river-borne traffic of the Murray and its tributaries is almost entirely controlled by South Australia, the question is one of importance to that State. Such was sufficiently obvious in the arguments during the Inter-State Commission, where the amount of the water to be diverted by the States of New South Wales and Victoria for irrigation was closely discussed. The New South Wales view of the question (where naturally enough *railway* transport is to a certain degree favoured by the authorities) is ably summed up by Mr. McKay.

'The trade consists of carrying stores to the towns, stations, and settlers located on the banks of the rivers, and bringing back wool, hides, tallow, and small quantities of farm produce. The trade of the Lower Murray and the river-borne traffic of the Darling centres in Morgan. The Upper Murray trade—which includes the river-borne traffic of the Murrumbidgee, Edwards, and Wakool Rivers—centres in Echuca, where excellent accommodation exists for the discharge and shipment of cargo.

'With a high river the Murray is practically navigable as far as Albury, but there is very little traffic beyond Echuca, which is 666 miles from the South Australian boundary. On the Darling steamers trade as far as Walgett, a distance of 1,180 miles from Wentworth. The

Murrumbidgee is navigable to Narandera, but it is only on rare occasions that steamers go beyond Hay.

'The gaugings at Morgan show that the Murray is, on an average, navigable for about seven months—July to January, inclusive—in the year. The Darling, however, only provides for very intermittent navigation, and it is not an uncommon sight to see boats stranded in the river channel for months at a time. Of late there has been a marked diminution in the volume of trade entering South Australia. This is due to the fact that owing to the drought the rivers have remained unnavigable for long periods, and also to the extension of railways. The Murray is now tapped by railways (see map) at Murray Bridge and Morgan in South Australia, and in New South Wales and Victoria the railways reach the river at Mildura, Swan Hill, Koondrook, Echuca, Cobram, Yarrawonga, Corowa, and Albury. The Darling is also tapped at Bourke, Brewarrina, Walgett, and Collarendabri, and railways are proposed to connect Wentworth and Wilcannia. With regard to the Murrumbidgee, the South Western Railway line which runs parallel to, and at a short distance from, the river, fulfils all the requirements of the trade of the Riverina country.'

The following returns, furnished by the Collector of Customs at Adelaide, will show the great decrease in the South Australian river trade with regard to inward and outward shipping, and the value of the imports and exports.

Year.	*Tonnage.*		*Imports.*	*Exports.*
	Outward.	*Inward.*		
1883	28,556	29,733	£664,167	£355,035
1892	23,504	23,345	425,706	131,293
1901	11,215	11,731	137,304	45,327

This is largely due to the *differential railway rates* for *river-district* produce which obtain even in South Australia. Thus it is stated that sugar sent to Echuca costs 50s. a ton if for *local* consumption; but if for the *Darling districts* it is carried for 11*s*. per ton, in order to compete with the cheap freight by the alternative water carriage. It must be borne in mind that a river must be 'efficient' before it can expect to become a profit-making means of transport. Hindered by a succession of dry seasons, culminating in 1902, the trade has been heavily handicapped. The sanguine anticipations of low rates competing with railway freights will not be realized until a system of locking the rivers provides not only for this difficulty, but for the more important one of irrigation. The Commission I have quoted so frequently made the following estimate of the cost of necessary works:

	Distance miles.	*No. of Locks.*	*Cost.*
Between Blanchetown and the border of South Australia	230	6	£600,000
From South Australian boundary to Echuca (Murray)	660	20	730,000
From Wentworth to Walgett (Darling locks)	1,180	24	920,000
From Murray Junction to Hay (Murrumbidgee locks)	238	9	321,750
	2,308	59	£2,571,750

Adding the lower course of the river (to Lake Alexandrina) we get a total length of 2,500 miles rendered navigable at a cost which will reach £3,000,000.

The question as to whether this is a legitimate investment of public funds can only be considered in connexion with that of irrigation. Under present conditions, where all the centres of population, except Menindie and Wentworth, are served by railways, it seems distinctly unprofitable. But having in view the flourishing settlements at Salt Lake City, to quote a single instance, where irrigation has made the desert bloom, one may hope good things from the locking of the rivers.

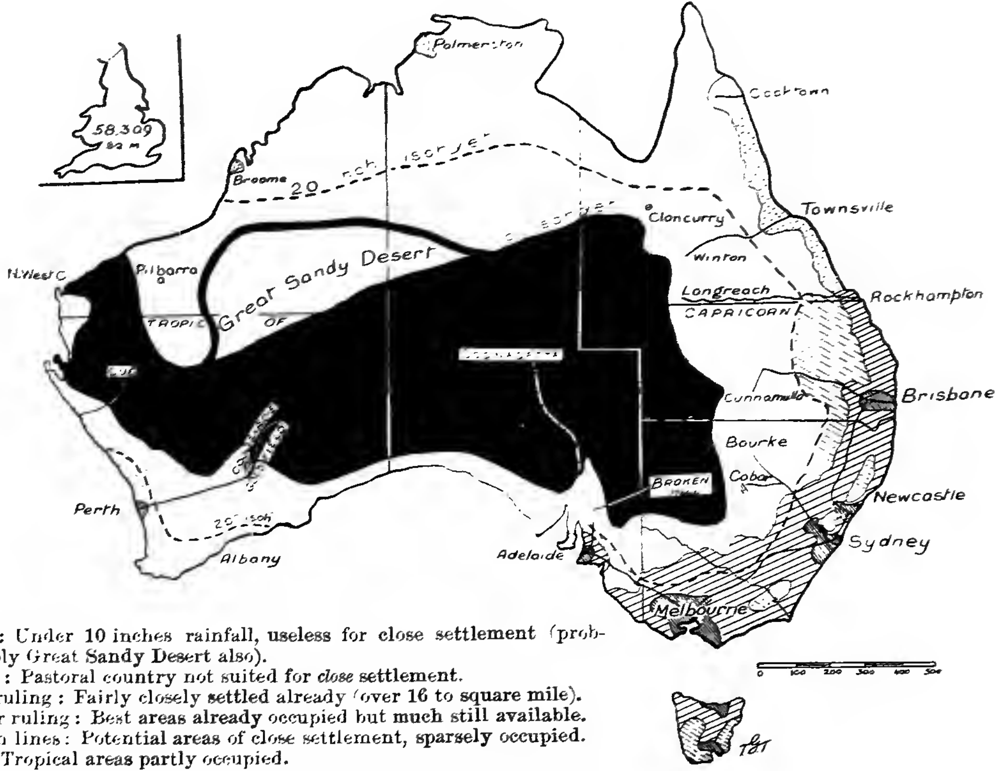
SECTION VI. FORECAST

CHAPTER XXV

FUTURE CLOSE SETTLEMENT IN AUSTRALIA

Having now completed our brief survey of the interaction of environment and industry in Australia, we may well devote some time to a consideration of future settlement in the Commonwealth. As no one can prophesy where profitable mining-fields are likely to occur—further than to say that there is no obvious reason why several more Kalgoorlies should not be found in the Great Arid Plateau of Australia—we may confine our attention to settlement due to agricultural and pastoral industries. Since the latter does not lead to *well-populated* districts in the strict sense of the word, we are more or less confined to regions where the climate is suitable for general farming and agricultural operations—in fact, to regions resembling those older countries where our white kindred have built towns and founded flourishing and well-established communities.

For the purpose of comparison we shall find it useful to turn to the United States of America. Here we have a country colonized by similar races, and situated in somewhat similar latitude. The relative areas are singularly alike, the United States, excluding Alaska, comprising 2,970,230 square miles, and Australia 2,974,581.



Black : Under 10 inches rainfall, useless for close settlement (probably Great Sandy Desert also).
White : Pastoral country not suited for *close* settlement.
Close ruling : Fairly closely settled already (over 16 to square mile).
Opener ruling : Best areas already occupied but much still available.
Broken lines : Potential areas of close settlement, sparsely occupied.
Dots : Tropical areas partly occupied.

FIG. 59. Future Close Settlement in Australia.

Unfortunately for Australia, the vital factor, rainfall, is by no means so generously allotted to the southern land. Probably only one-tenth of the U.S.A. has an annual rainfall of less than 10 inches, while in Australia over 1,000,000 square miles, or 42 % of the whole, consists of such arid country (see Fig. 59).

One of the most promising features of Australian growth is the way in which some of those in authority are cheerfully facing the fact that Australia *is* a land of drought as regards a large portion of its area. One could point to good results already resulting from this recognition. The danger of over-stocking in New South Wales is much less than was the case formerly. Money is being spent on water conservation on a much larger scale than ever before. Railways which tap the main wool-growing districts are being pushed forward to move sheep to areas of better pasture in time of drought, and so on.

Still, many people do not realize that rainfall is of paramount importance for all industries except mining. It seems a trifle misleading to publish comparative maps of Western Australia (for instance) and Great Britain, for the purpose of showing the extensive areas of land awaiting development in that State. As a matter of fact, of the 1,000,000 square miles comprised in Western Australia, only about 17 % has a rainfall comparable with that of the British Isles (i.e. over 20 inches), and of this area (but a little greater than that of the British Isles) no less than four-fifths is situated within the tropic.

A glance at a map of Australia will show that after nearly a century of steady progress, settlement is still confined to certain definite areas. It will be worth while to consider the reasons for this distribution. The sketch-map (Fig. 59) indicates by the ruled and dotted areas those districts which are more than sparsely populated and contain more than one inhabitant to the square mile. (Data from the *Commonwealth Year Book.*)

What factor is common to all these areas? It will be seen that, with three or four exceptions, they all lie outside the 20-inch isohyet. Australians must always bear in mind that a large part of the continent, somewhere about 40%, will never support aught but a nomadic pastoral occupation, flourishing in occasional (and exceptional) rainy seasons, and only in the case of large holdings, managing to tide over the lean years. Indeed, what can be expected with the 10-inch isohyet, sweeping from North-West Cape across the heart of the continent almost to Cloncurry, and then bending southwards towards Bourke and the Murray mouth? All to the south and west of this line, except two broad coastal areas in the west (Perth and Pilbarra), and another around the South Australian Gulfs, are beyond reclamation for profitable settlement on any large scale.[1]

With the United States as an example of what will presumably eventuate in Australia, let us attempt to define the limits of *close* settlement more accurately. We may omit all areas receiving less than 20 inches of rain per annum in this broad investigation. The question of temperature is also of importance, and admits of several methods of treatment. One may use a definite mean annual isotherm as a criterion. Referring to U.S.A. it is seen that the line 68° F. passes just north of New Orleans and Florida. It will be admitted that these districts are not well suited for *continuous* out-of-door white labour, or at any rate British labour; and the white Australia policy at present does not favour 'dago' immigration from Southern Europe. In Australia this isotherm

[1] Certain exceptions, such as the mining settlements of Coolgardie, Cue, Broken Hill, &c., have prospered in the face of most unfavourable conditions, although they lie within the 10-inch isohyet.

of 68° passes south of the Tropic of Capricorn,[1] so that one may safely take the latter as the northern limit of the most favourable areas for closer settlement in Australia.

Now let us tabulate these areas available for settlement by the British farmer. They are shown by the diagonally-ruled areas on the map (Fig. 59). (It is useful to remember that the British Isles have an area of 120,000 square miles.)

Table A.

Areas suitable for close settlement.

(Temperate lands with annual rainfall over 20″.)

New South Wales . . .	113,000 sq. miles.
Queensland	80,000 ,,
Victoria.	52,000 ,,
West Australia . . .	33,000 ,,
Tasmania	26 000 ,,
South Australia . .	15,000 ,,
Total	319,000 sq. miles.

No exception is made for rugged or heavily timbered country in this list. Such will naturally be later portions of the State to be settled.

Let us now compare this area with the similar tract in U.S.A., and endeavour to draw a parallel between the growth of the latter and that foreshadowed in Australia.

In 1800 the United States had a population of 5,000,000—which is much the same as that occupying Australia now—and during the past century (1800–1900) it has increased to 76,000,000. The distribution of the latter is controlled to a very great extent by the rainfall, as will be seen from the sketch-map (Fig. 60) where the '6 to the

[1] The annual isotherm 68° lies about 33° N. latitude but 26° S. latitude, showing that the Southern Hemisphere is in general much cooler than corresponding latitudes in the Northern Hemisphere.

square mile' population-line[1] almost coincides with the 20-inch isohyet and the 18 isopleth[1] runs parallel and less than 100 miles to the east.

This 20-inch isohyet practically divides U.S.A. into equal areas of some 1,500,000 square miles each. In the western half (i.e. the twelve States including and west of Dakota, Nebraska, Colorado, and New Mexico) are dis-

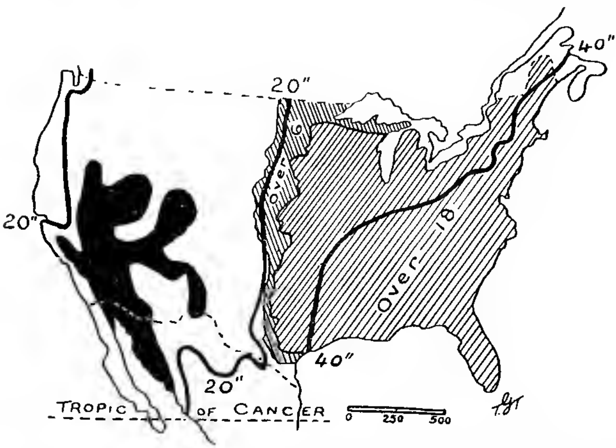


FIG. 60. Correlation of Rainfall and Population in U.S.A. The thick lines are isohyets of 40 and 20 inches. The black area has less than 10 inches of rain. The line rulings show the density of population and are based on Bartholomew's map.

tributed only seven per cent. of the whole population while 70,000,000 have settled in the well-watered eastern half.

In Australia, as we have seen, there are about 400,000 square miles of well-watered *temperate* country, or about one-quarter of that in U.S.A. So that given the same

[1] The distribution of population is an important factor in questions of applied geography. A convenient term—akin to isobar, &c.—seems to be needed, such as isopleth from πλῆθος, population. (Cf. Euripides, *Phoen.* 715 σμικρὸν τὸ πλῆθος τῆσδε γῆς.)

rate of increase as in U.S.A.—which, however, is not likely to occur—Australia should have a population of some 19,000,000 white people at the end of the century.

If, however, we recognize the undoubted value of the tremendous areas of fertile and reasonably watered country in the tropical portion of Australia, the larger colonies stand in a much more favourable position. Without coloured labour, however, it is difficult to see how such crops as cotton, rice, tea, coffee, tobacco, and rubber can be grown with any great profit, even if supported by Government bounties, yet, as explained in an earlier section, these products are the main resources of regions with a similar climate.

Table B.

(Total areas of land with more than 20″ rain annually.)

Queensland	280,000 sq. miles.[1]
South Australia	215,000 ,,
West Australia	150,000 ,,
New South Wales	113,000 ,,
Victoria	52,000 ,,
Tasmania	26,000 ,,
Total	836,000 sq. miles.

Thus under present political conditions New South Wales is the most promising field for future settlement, with Queensland a close second, as shown on Table A. If the tropical areas are thrown open to inferior labour—which alone is profitable on a large scale—then Queensland occupies the most favourable position, while South Australia moves from the last to the second place.

It will be probably remarked that Australia must rely

[1] The figures for the Northern Territory given in the *Commonwealth Year Book* (p. 121) are absolutely incomprehensible when compared with the areas on the map (*vide* 0–10″ and 30″–40″ areas).

chiefly on her pastoral area for her future wealth. The more settled portion of Australia in the south-east has already suffered from over-stocking, but in the north and west there is still ample room for expansion. Though sheep prefer the less tropical portions, cattle thrive excellently in the far north, and it seems probable that it will be the latter class of stock which will increase in numbers to a greater degree in the future.

Before proceeding to gain some idea of the pastoral areas available in Australia some discussion of the official rainfall maps (Fig. 13)—on which this chapter is based—is necessary. As mentioned previously (p. 47) the latest Map (Commonwealth, for the decade 1897–1906) shows great alterations in the position of the 10-inch isohyet. A large area in the West of New South Wales and Queensland has been added to the central arid tract. This may be due to the influence of the great drought of 1902–3, and perhaps the next decade will yield happier results.

Another alteration—involving an area nearly as large as New South Wales—is, however, not so readily understood. About 200,000 square miles in Western Australia (shown by the thick black line enclosing the Great Sandy Desert in Fig. 59) have been transferred without explanation to the Pastoral zone (10″–20″) in the official map in the *Commonwealth Year Book.* In their separate *large-scale* Rainfall map the region is indicated as furnishing incomplete data, but to my mind the evidence, such as it is, certainly points to the retention of this 200,000 square miles within the arid (less than 10″) region as in previous maps.

Only three explorers (Warburton, Wells, and Carnegie) had even crossed the region up to 1897, and I am unable to published by explorers seem to show that the vegetation is as scanty and the water supply as evanescent as in the driest portions of the continent.[1]

In the present section I shall therefore class this doubtful area (X A B Y in Fig. 13) as *useless* arid country, and my opinion is strengthened by the fact that large tracts on the east of the desert—which have *undoubtedly less* than a 10-inch rainfall, seem much more suitable for pastoral occupation.

The States may be classed approximately as follows in regard to their pastoral capabilities under present political conditions.

PASTORAL AREAS.

States.	*Good Pastoral,* 10″–20″.	*Arid, useful in good seasons.*	*Tropical, over* 20″.	*Total.*	*Now occupied, approximate.*
	A	B	C	D	E
West Australia	265,000	230,000	120,000	615,000	230,000
Queensland	230,000	160,000	200,000	590,000	300,000
South Australia	185,000	106,000	200,000	491,000	290,000
New South Wales	113,000	84,000	—	197,000	150,000
Victoria	36,000	—	—	36,000	50,000
Tasmania	—	—	—	—	7,000
Totals	829,000	580,000	520,000	1,929,000	1,027,000

In opening up a new country it is obvious that pioneer industries such as sheep and cattle rearing will occupy lands which later on will be more economically utilized in other ways. This applies to much of the well-watered

[1] Recent reports from prospectors are to the effect that this is a little better country than the narratives of earlier explorers would lead us to expect.—ED.

areas given in columns C and E in the above table. For instance a large portion of Tasmania now devoted to sheep will undoubtedly be converted into farms and orchards in the near future.

To sum up the approximations I have attempted to demonstrate in this section. There is in Australia an area (320,000 square miles) about three times that of Great Britain, of sufficiently similar climate and rainfall to admit of fairly close settlement for farming and allied industries. The population on the area is still very scanty, though naturally the best lands have been alienated. Moreover, much included in the area is rocky and barren, the figures obtained depending purely on conditions of rainfall and climate generally.

An area of nearly 1,000,000 square miles has a rainfall greater than 20 inches per year, but unfortunately more than half of this tract lies north of the Tropic of Capricorn and cannot be profitably exploited without inferior labour. For instance it can never under *white* labour compete with the similar agricultural lands of tropical India.

It may safely be assumed, however, that much will be utilized for raising cattle; while of drier areas more or less suitable for grazing, there are in addition probably over 1,000,000 square miles available.

If, however, we neglect political factors—such as the White Australia policy—and consider only the unrestrained potentialities of the Six States, we arrive at the succeeding table:—

POTENTIAL OCCUPATION OF AUSTRALIA.

States.	*Available for close* **White** *settlement.*	*Available for close* **Coloured** *settlement.*	*Good pastoral lands.*	*Arid pastoral land, under 10″.*	*Useless desert.*	*Total.*
West Australia	33 000	120,000	265,000	230,000	328,000	976,000
South Australia	15,000	200,000	185,000	106,000	398,000	904,000
Queensland	80,000	200,000	230,000	160,000	—	670,000
New South Wales	113,000	—	113,000	84,000	—	310,000
Victoria	52,000	—	36,000	—	—	88,000
Tasmania	26,000	—	—	—	—	26,000
Totals	319,000	520,000	829,000	580,000	726,000	2,974,000
Per cent. of whole	10·7	17·2	27·9	19·6	24·6	100

These results may be finally condensed as follows :—

44 % is *Arid*, of which :—

- $24\frac{1}{2}$ % of the Continent is useless, and
- $19\frac{1}{2}$ % is useless in bad seasons.

17 % is suited for *tropical agriculture.* (This is ten times the area of Java, which has 30,000,000 inhabitants)

39 % is suited for *Profitable White Settlement*, of which:—

- 28 % is good pastoral country.
- 11 % is good temperate farming country.

CONCLUSION.

Here I close this brief study of the resources of Australia. I have viewed the problems which have arisen from the economic point of view rather than from the political; from the academic rather than the farmer's standpoint. Several important factors have been omitted in the section dealing with the future of Australia—of which the manufacturing industry which must arise along the Eastern Coal-Belt is not the least. Australia must make the most of the garland of verdure which surrounds her arid interior. Water conservation and dry farming will broaden this garland. Intense cultivation will produce a yeoman class and promote decentralization. With regard to the tropics, although in the near future cattle will surely utilize the savanas, may we not look forward to the time when—escaping the errors of less fortunate countries—we allow a confined but contented weaker race to develop our wasted northern areas.

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